To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: http://www.renesas.com

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (http://www.renesas.com)

Send any inquiries to http://www.renesas.com/inquiry.

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of 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. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. 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 of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may 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.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: "Standard", "High Quality", and "Specific". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as "Specific" without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as "Specific" or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is "Standard" unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

   "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.

   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.

   "Specific": Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, 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, please evaluate the safety of the final products or system 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. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

740 Family

Recommended PCB Layout for Anti-noise

1. Abstract

The following article introduces how to design a printed-circuit board (PCB) layout to get enhance anti-noise performance, and shows a test to compare the different effects of two kinds of PCB layout (recommended and non-recommended layout) under the same noise interference and how to improve the not recommended board.

2. Introduction

The explanation of this issue is applied to the following condition:

- MCU type: 740 family MCU

The test results are applied to the following conditions:

- Sample MCU: M37544G2ASP
- Oscillation frequency: 4 MHz
- PCB type: Single-sided board without polygon

3. Recommended PCB layout

Examples of the recommended layout and non-recommended one are shown in this article. There are some points indicating how to reduce noise by designing an appropriate PCB layout. With these points, our product's anti-noise performance can be improved.

3.1 Examples of PCB layout

In this section, some examples show the differences between the recommended layout and non-recommended one. Both board's schematics are the same.
The schema of the circuits around MCU is shown below:

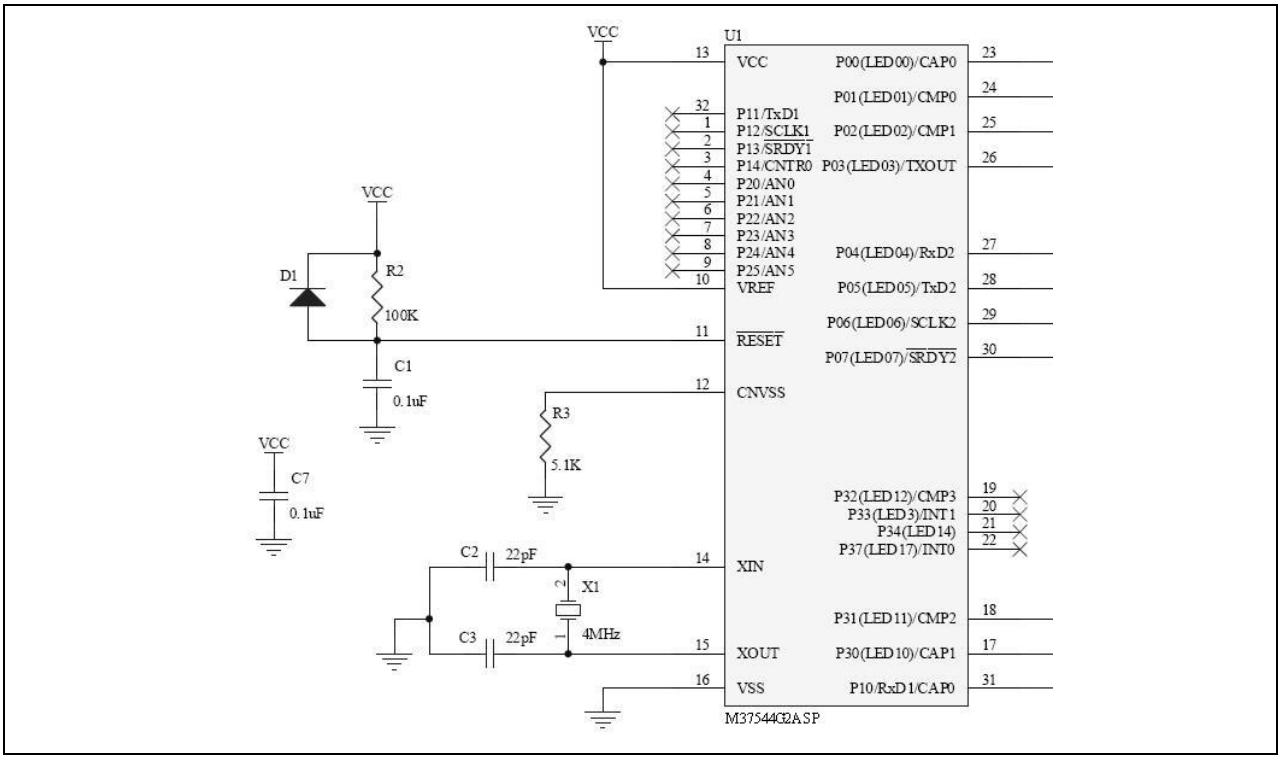


Figure 1 Schema of MCU Part

The main differences are shown from number one to five in the Figure 2. The PCB layout should be designed in accordance with recommended one to achieve better performance. The reasons why the PCB layout on the left is recommended are elaborated in next part (3.2 Recommended layout).

The PCB layout are shown below:

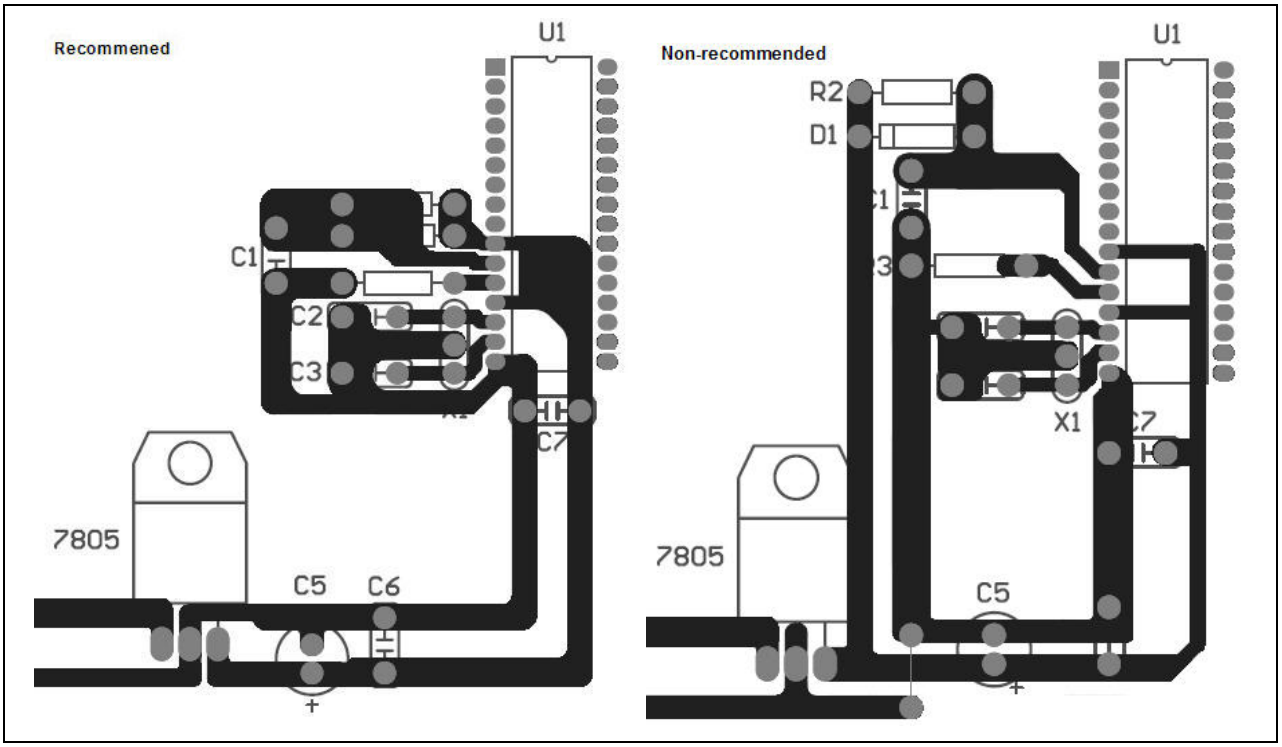


Figure 2 Recommended Layout (Left) and Not Recommended Layout (Right)

Note:
Both of the PCB layouts shown above have been tested.
Component package: DIP
PCB type: Single layer board without polygon

3.2 Recommended layout

Here are some PCB design principles to reduce the noise effect.

3.2.1 Oscillator circuit

To reduce the noise effect, the oscillator wirings pattern should be as short to MCU as possible. The wiring pattern of VSS line for oscillator and MCU should be separated from other peripheral's VSS pattern. Refer to Figure 2 (number 1 in the yellow circle).

<Reason>: Long wires may have an antenna effect to catch large noise. If noise enters the clock I/O pins, clock waveform may be deformed. This may cause a program failure or runaway. Also if the potential difference is caused by the noise between the oscillator VSS level and a MCU VSS level, the correct clock will not be input in the MCU.

3.2.2 Reset circuit

In the same way, the reset circuit should be as close to MCU as possible. Refer to Figure 2 (number 2 in the green circle).

<Reason>: The reset signal initializes the internal MCU state. If fine, noise-like pulses pass through the reset signal line, the MCU may not completely initialize (partially initialized). It is better to shorten the wiring for the reset circuit to reduce the noise influence.

3.2.3 CNVSS circuit

Use a 1k - 5kΩ serial connection to connect the CNVSS/VPP pin to the VSS pattern. Make the length of wiring pattern from the resister to the CNVSS/VPP pin as short as possible. Refer to Figure 2 (number 3 in the pink circle).

<Reason>: If noise occurs in the CNVSS/VPP pin, the MCU may runaway.

3.2.4 Decoupling capacitor

Place the decoupling capacitor close to the MCU. Connect the capacitor across the VCC and the VSS pin in equal length. Refer to Figure 2 (number 4 in the orange circle).

<Reason>: If the MCU decoupling capacitor wiring is long, it should be noted that the line may become a noise antenna.

3.2.5 VSS wiring pattern

Wire the MCU VSS, the oscillator, the reset circuit and CNVSS pin in the same VSS branch. Refer to Figure 2 (number 5 in the brown circle).

<Reason>: If the potential difference is caused by the noise of two different VSS circuits, the program may generate a failure or runaway.

4. Anti-noise test of different layout

4.1 Test description

In this test, two types of PCB were used. One is designed according to the recommendations. The other is designed on the contra. The PCB layout around the MCU are shown above. The peripheral circuits on the two boards are the same. Equal noise interference is input to the two test boards through the power supply for one minute. The peak value of noise interfere is steps up in 100V increments from 100V to 4000V in every test.

On the target boards, there are two groups of LED lamps that blink to show the MCU status. All LED lamps will blink for five second after the MCU reset. Then the two groups of LED lamps will blink from "0000_2" to "1111_2" by "1_2". One group is controlled by the main loop; the other group is controlled by the timer interrupt. These two groups of LED lamps will blink synchronously.

The MCU status can be evaluated by observing these LED lamps.

- If the MCU operates normally within one minute, the result is considered good and the table is filled with an "○".
- If the MCU generates a phenomena (reset, program runaway or LED lamps blink asynchronously) within one minute, the result is considered not good and the table is filled with an "×".

The diagram of test environment is shown below:

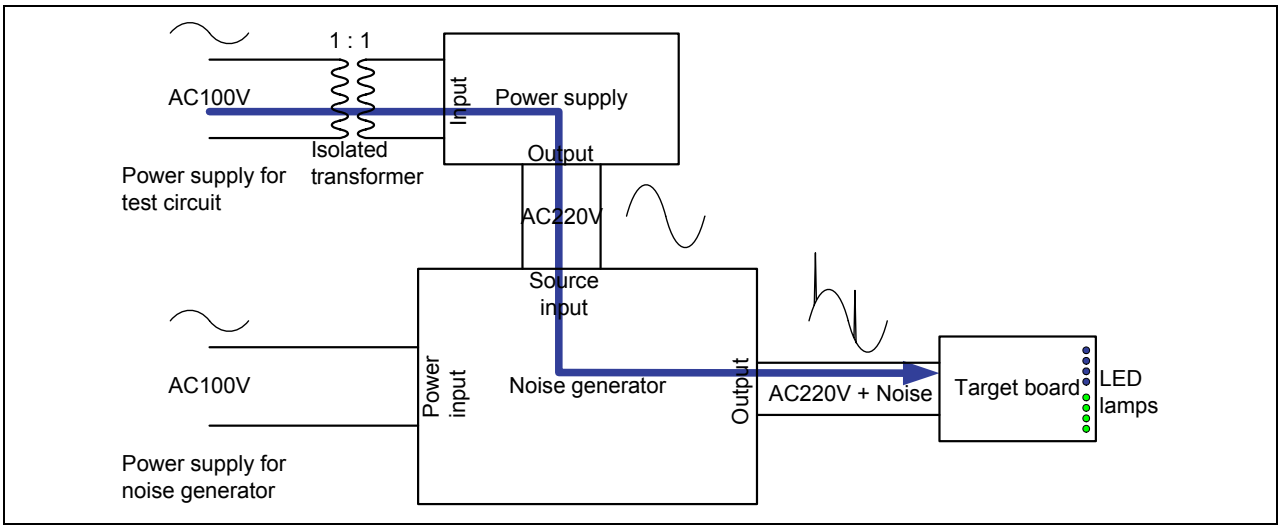


Figure 3 Diagram of Test Environment

4.2 Test conditions

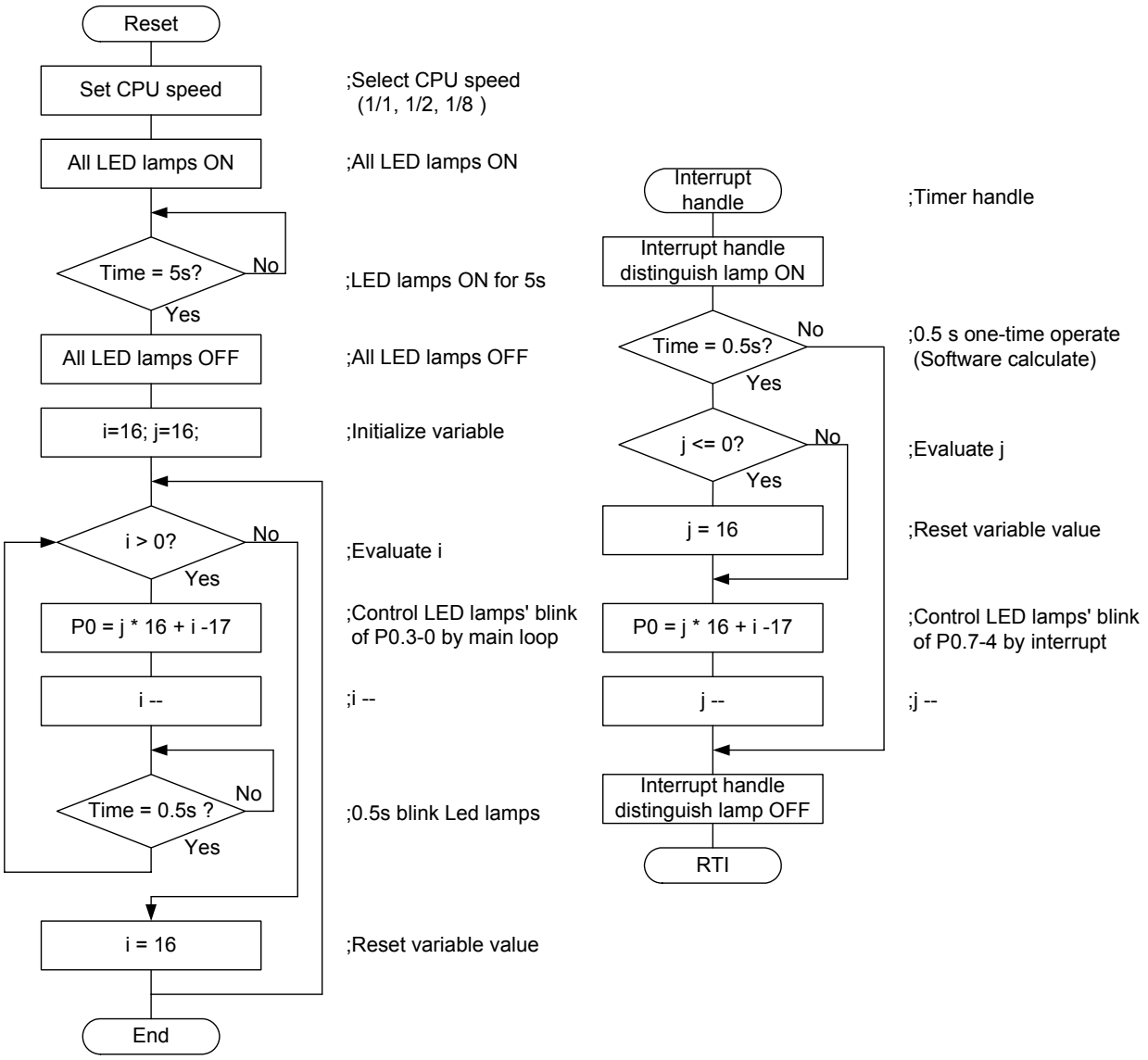
- Test tools:

—Power supply: CVFT1-200H
—Noise generator: NoiseKen INS-4001
—Target board: Recommended and non-recommended board

- Test conditions:

—Target board power: 220 V 50 Hz
—MCU type: M37544G2ASP
—Oscillation frequency: 4 MHz
—MCU speed: f(xin)/1, f(xin)/2 and f(xin)/8
—MCU power source: 5 V
—MCU decoupling capacitor: 0.1 uF
—Noise period: 10 ms
—Noise pulse width: 50 ns
—Noise polarity: plus and minus
—Noise peak value: 100 V to 4000 V (The maximum noise peak of the noise generator is 4000 V)
—Test time: 1minute

4.3 Test program flow chart



4.4 Test results

Table 1: Test Results of Two PCB Layouts

Layout	Recommend Board Test Results						Non-Recommend Board Test Results					
Polarity / Voltage	+			-			+			-		
4000	×	○	○	×	×	○	×	×	×	×	×	×
3900	×	○	○	×	×	○	×	×	×	×	×	×
3800	× (2)	○	○	×	× (2)	○	×	×	×	×	×	×
3700	○	○	○	×	○	○	×	×	×	×	×	×
3600	○	○	○	×	○	○	×	×	×	×	×	×
3500	○	○	○	× (2)	○	○	×	×	×	×	×	×
3400	○	○	○	○	○	○	×	×	×	×	×	×
3300	○	○	○	○	○	○	×	×	×	×	×	×
3200	○	○	○	○	○	○	×	×	×	×	×	×
3100	○	○	○	○	○	○	×	×	×	×	×	×
3000	○	○	○	○	○	○	×	×	×	×	×	×
2900	○	○	○	○	○	○	×	×	×	×	×	×
2800	○	○	○	○	○	○	×	×	×	×	×	×
2700	○	○	○	○	○	○	×	×	×	×	×	×
2600	○	○	○	○	○	○	×	×	×	×	×	×
2500	○	○	○	○	○	○	×	×	×	×	×	×
2400	○	○	○	○	○	○	×	×	×	×	×	×
2300	○	○	○	○	○	○	×	×	×	× (1)	×	×
2200	○	○	○	○	○	○	×	×	×	× (2)	×	×
2100	○	○	○	○	○	○	×	×	×	× (2)	×	×
2000	○	○	○	○	○	○	×	×	×	× (2)	×	×
1900	○	○	○	○	○	○	×	×	×	× (2)	× (1)	×
1800	○	○	○	○	○	○	×	×	×	× (2)	○	×
1700	○	○	○	○	○	○	× (1)	×	×	× (2)	○	×
1600	○	○	○	○	○	○	× (2)	×	×	× (2)	○	×
1500	○	○	○	○	○	○	× (2)	×	× (1)	× (2)	○	×(1)
1400	○	○	○	○	○	○	× (2)	× (1)	○	× (2)	○	○
1300	○	○	○	○	○	○	× (2)	○	○	× (3)	○	○
1200	○	○	○	○	○	○	× (2)	○	○	○	○	○
1100	○	○	○	○	○	○	× (2)	○	○	○	○	○
1000	○	○	○	○	○	○	× (3)	○	○	○	○	○
900	○	○	○	○	○	○	○	○	○	○	○	○
800	○	○	○	○	○	○	○	○	○	○	○	○
700	○	○	○	○	○	○	○	○	○	○	○	○
600	○	○	○	○	○	○	○	○	○	○	○	○
500	○	○	○	○	○	○	○	○	○	○	○	○
400	○	○	○	○	○	○	○	○	○	○	○	○
300	○	○	○	○	○	○	○	○	○	○	○	○
200	○	○	○	○	○	○	○	○	○	○	○	○
100	○	○	○	○	○	○	○	○	○	○	○	○
Voltage / CPU Speed	1/1	1/2	1/8	1/1	1/2	1/8	1/1	1/2	1/8	1/1	1/2	1/8

Note:
Voltage: Noise value (Higher value shows higher anti-noise capability)
Polarity: Noise polarity added to target board power source
CPU speed: Clock division ratio selection: f(xin)/1, f(xin)/2 and f(xin)/8
○: Normal MCU operation
× (1): Reset cannot be released; × (2): Reset → restart → reset; × (3): Main loop error or runaway

4.5 Test conclusions

The test results show the anti-noise performance of the boards tested. Resistance to noise interference on the recommended board is about 4000 V (the maximum value of the noise generator), and that on the not-recommended board is below 2000 V.

Conclusions obtained from this test are as follows:

- Higher anti-noise performance is achieved by designing a PCB layout according to the recommendations.
- For the same CPU speed, a high frequency oscillator with a high clock division ratio should be used to achieve good anti-noise performance.

Note:

Keep the MCU away from high voltage noise, even if it is designed on the recommended PCB layout. The test results are available only to distinguish the effects noise has on different types of layouts and do not represent MCU performance.

5. Improve the Non-recommended board

After the above test, modifications were made on some circuit bases on the non-recommended board and tested again under same conditions.

In this test, the non-recommended PCB board was provisionally modified to improve anti-noise performance. In developing a product, if possible, the PCB layout should be redesigned according to the recommended layout to achieve good performance.

5.1 Modification of the Non-recommended board

Modified items are listed below:

- Oscillator circuit: Cut off the original wiring pattern which connects to the VSS and connect the oscillator to the MCU VSS with a jumper to shorten the VSS wiring pattern of the oscillator circuit. Refer to the modification in the yellow section in the Figure 4.
- Reset circuit: Remove the components of the reset circuit and weld those components to the back side of the board at the short distance. Refer to the modification in the green section in the Figure 4.
- CNVSS circuit: Remove the CNVSS resister and weld it to the back side of the board to shorten the distance of the VSS wiring. Refer to the modification in the pink section in the Figure 4.
- VSS wiring pattern: Connect the VSS wiring of the MCU, the oscillator, the reset circuit and the CNVSS pin to the same VSS branch. Refer to the modification in the brown section in the Figure 4.

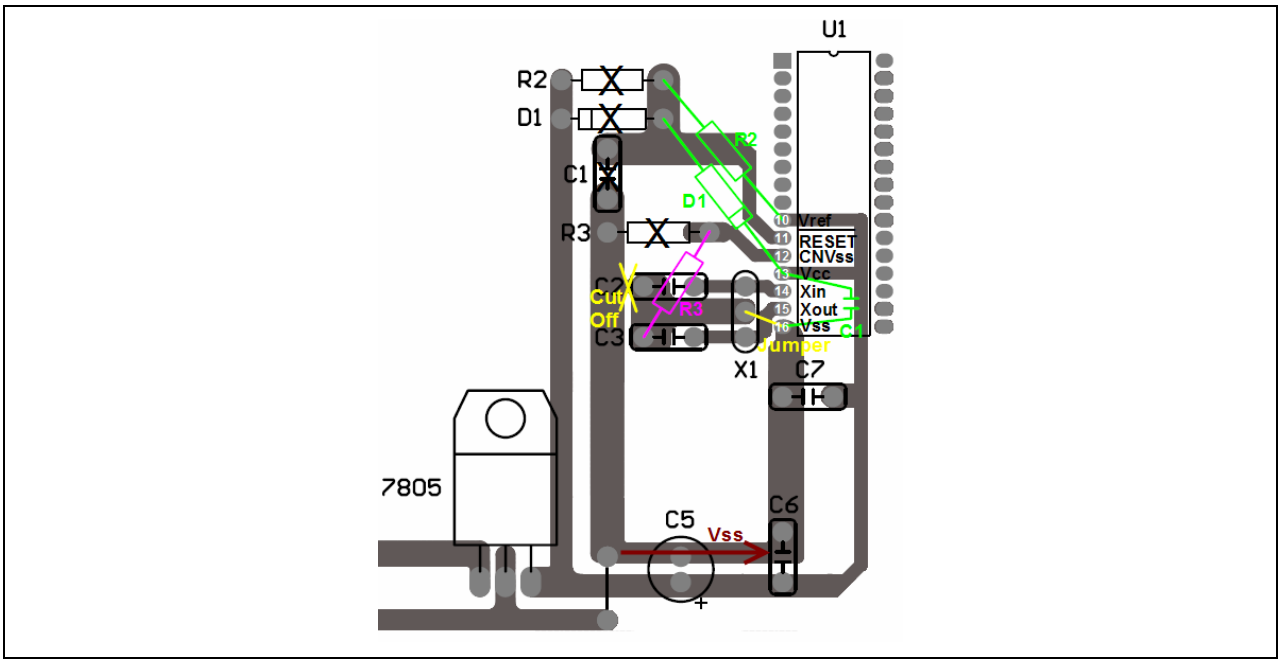


Figure 4 Improve the Non-recommended Board

5.2 Test results of modified board

Table 2 Comparison between Before and After Modification

Non-recommended Layout	After Modification						Before Modification					
Polarity / Voltage	+			-			+			-		
4000	×	○	○	×	×	×	×	×	×	×	×	×
3900	×	○	○	×	×	×	×	×	×	×	×	×
3800	×	○	○	×	×	×	×	×	×	×	×	×
3700	×	○	○	×	×	×	×	×	×	×	×	×
3600	×	○	○	×	×	×	×	×	×	×	×	×
3500	×	○	○	×	×	×	×	×	×	×	×	×
3400	×	○	○	×	× (2)	×	×	×	×	×	×	×
3300	×	○	○	×	○	× (2)	×	×	×	×	×	×
3200	×	○	○	×	○	○	×	×	×	×	×	×
3100	×	○	○	×	○	○	×	×	×	×	×	×
3000	×	○	○	×	○	○	×	×	×	×	×	×
2900	×	○	○	×	○	○	×	×	×	×	×	×
2800	× (2)	○	○	×	○	○	×	×	×	×	×	×
2700	○	○	○	× (2)	○	○	×	×	×	×	×	×
2600	○	○	○	○	○	○	×	×	×	×	×	×
2500	○	○	○	○	○	○	×	×	×	×	×	×
2400	○	○	○	○	○	○	×	×	×	×	×	×
2300	○	○	○	○	○	○	×	×	×	× (1)	×	×
2200	○	○	○	○	○	○	×	×	×	× (2)	×	×
2100	○	○	○	○	○	○	×	×	×	× (2)	×	×
2000	○	○	○	○	○	○	×	×	×	× (2)	×	×
1900	○	○	○	○	○	○	×	×	×	× (2)	× (1)	×
1800	○	○	○	○	○	○	×	×	×	× (2)	○	×
1700	○	○	○	○	○	○	× (1)	×	×	× (2)	○	×
1600	○	○	○	○	○	○	× (2)	×	×	× (2)	○	×
1500	○	○	○	○	○	○	× (2)	×	× (1)	× (2)	○	×(1)
1400	○	○	○	○	○	○	× (2)	× (1)	○	× (2)	○	○
1300	○	○	○	○	○	○	× (2)	○	○	× (3)	○	○
1200	○	○	○	○	○	○	× (2)	○	○	○	○	○
1100	○	○	○	○	○	○	× (2)	○	○	○	○	○
1000	○	○	○	○	○	○	× (3)	○	○	○	○	○
900	○	○	○	○	○	○	○	○	○	○	○	○
800	○	○	○	○	○	○	○	○	○	○	○	○
700	○	○	○	○	○	○	○	○	○	○	○	○
600	○	○	○	○	○	○	○	○	○	○	○	○
500	○	○	○	○	○	○	○	○	○	○	○	○
400	○	○	○	○	○	○	○	○	○	○	○	○
300	○	○	○	○	○	○	○	○	○	○	○	○
200	○	○	○	○	○	○	○	○	○	○	○	○
100	○	○	○	○	○	○	○	○	○	○	○	○
Voltage / CPU Speed	1/1	1/2	1/8	1/1	1/2	1/8	1/1	1/2	1/8	1/1	1/2	1/8

Note:
Voltage: Noise value (Higher value shows higher anti-noise capability)
Polarity: Noise polarity added to target board power source
CPU speed: Clock division ratio selection f(xin)/1, f(xin)/2 and f(xin)/8)
○: Normal MCU operation
× (1): Reset cannot be released; × (2): Reset → restart → reset; × (3): Main loop error or runaway

5.3 Recommendations for improved PCB board

After modifications are made to the circuits on the non-recommended board, the results of anti-noise performance improves drastically but fell short of that of the recommended board. Given these result, it is recommended that in developing a product, the PCB should be redesign based on the recommended layout.

Note the following precautions for designing the PCB layout.

- Oscillator circuit wiring pattern: Use the shortest wiring pattern to connect oscillator, capacitor and MCU.
- Reset circuit wiring pattern: Place the reset circuit as close to the MCU as possible.
- CNVSS wiring pattern: Use a serial connection to connect a resister to the CNVSS pin and the MCU VSS with the shortest wiring possible.
- Wiring pattern of VSS: Place the VSS wiring pattern of the oscillator, reset, and CNVSS circuits in the same VSS branch and separate them from other VSS wiring patterns.

Website and Support

Renesas Technology Website
http://www.renesas.com/

Inquires
http://www.renesas.com/inquiry
csc@renesas.com

Hardware manual
M37544 Group datasheet
Use the latest version from the Renesas homepage: http://www.renesas.com

Technical update/Technical news
Use the latest information from the Renesas homepage: http://www.renesas.com

Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	Aug.21.06	-	First edition issued

Keep safety first in your circuit designs!

1. Renesas Technology Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage.
   Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of nonflammable material or (iii) prevention against any malfunction or mishap.

Notes regarding these materials

1. These materials are intended as a reference to assist our customers in the selection of the Renesas Technology Corporation product best suited to the customer's application; they do not convey any license under any intellectual property rights, or any other rights, belonging to Renesas Technology Corporation or a third party.
2. Renesas Technology Corporation assumes no responsibility for any damage, or infringement of any third-party's rights, originating in the use of any product data, diagrams, charts, programs, algorithms, or circuit application examples contained in these materials.
3. All information contained in these materials, including product data, diagrams, charts, programs and algorithms represents information on products at the time of publication of these materials, and are subject to change by Renesas Technology Corporation without notice due to product improvements or other reasons. It is therefore recommended that customers contact Renesas Technology Corporation or an authorized Renesas Technology Corporation product distributor for the latest product information before purchasing a product listed herein.
   The information described here may contain technical inaccuracies or typographical errors.
   Renesas Technology Corporation assumes no responsibility for any damage, liability, or other loss rising from these inaccuracies or errors.
   Please also pay attention to information published by Renesas Technology Corporation by various means, including the Renesas Technology Corporation Semiconductor home page (http://www.renesas.com).
4. When using any or all of the information contained in these materials, including product data, diagrams, charts, programs, and algorithms, please be sure to evaluate all information as a total system before making a final decision on the applicability of the information and products. Renesas Technology Corporation assumes no responsibility for any damage, liability or other loss resulting from the information contained herein.
5. Renesas Technology Corporation semiconductors are not designed or manufactured for use in a device or system that is used under circumstances in which human life is potentially at stake. Please contact Renesas Technology Corporation or an authorized Renesas Technology Corporation product distributor when considering the use of a product contained herein for any specific purposes, such as apparatus or systems for transportation, vehicular, medical, aerospace, nuclear, or undersea repeater use.
6. The prior written approval of Renesas Technology Corporation is necessary to reprint or reproduce in whole or in part these materials.
7. If these products or technologies are subject to the Japanese export control restrictions, they must be exported under a license from the Japanese government and cannot be imported into a country other than the approved destination.
   Any diversion or reexport contrary to the export control laws and regulations of Japan and/or the country of destination is prohibited.
8. Please contact Renesas Technology Corporation for further details on these materials or the products contained therein.