ZMID4200MROT36001
Rotary Application Module

Description

The ZMID4200 application modules provide an easy demonstration of Renesas' ZMID4200 inductive sensing solutions for specific application cases. The typical sensor performance for a defined application use case can be evaluated via reference measurements performed with the application module.

Renesas' ZMID4200MROT36001 Rotary Application Module demonstrates inductive rotary position sensing. The Application Module can be programmed for a specific application range using ZMID-COMBOARD, which is separately available.

The Rotary Application Module Sensor PCB can be easily attached to an existing mechanical configuration for prototyping.

Kit Contents

- Rotary Application Module Sensor PCB
- Sensor Target, Target Holder, Rotation Axis, and Knob
- Module Connection Cable
- *Quick Start Guide* and *Kit Disclaimer*

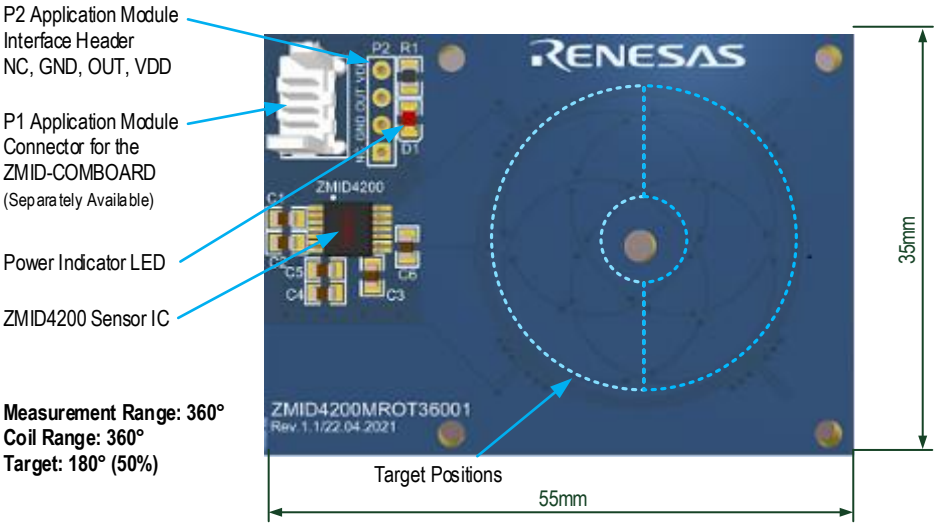
Features

- Easy application prototyping
- Measurement reports available.
- Programmable output slope and linearization
- Tolerance to mechanical misalignment
- No magnets required; reduces cost
- Module design data, *ZMID4200 EVK Application Software*, and user manual available online depending on the module: http://www.renesas.com/ZMID4200stkit

Rotary Module Summary

- Measurement range: 360° (using a 50% target)
- Output resolution:
  - 10-bit Analog Output = 0.35°
  - 10-bit PWM Output = 0.35°
  - 12-bit SENT Output = 0.09°

ZMID4200MROT36001 Rotary Application Module Sensor PCB



Important Notes

Disclaimer

Integrated Device Technology, Inc. and its affiliated companies (herein referred to as "Renesas") shall not be liable for any damages arising out of defects resulting from

(i) delivered hardware or software

(ii) non-observance of instructions contained in this manual and in any other documentation provided to user, or

(iii) misuse, abuse, use under abnormal conditions, or alteration by anyone other than Renesas.

TO THE EXTENT PERMITTED BY LAW, Renesas HEREBY EXPRESSLY DISCLAIMS AND USER EXPRESSLY WAIVES ANY AND ALL WARRANTIES, WHETHER EXPRESS, IMPLIED, OR STATUTORY, INCLUDING, WITHOUT LIMITATION, IMPLIED WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE, STATUTORY WARRANTY OF NON-INFRINGEMENT, AND ANY OTHER WARRANTY THAT MAY ARISE BY REASON OF USAGE OF TRADE, CUSTOM, OR COURSE OF DEALING.

Restrictions in Use

ZMID520xMROT36001 Rotary Application Module, consisting of the Rotary Application Module Sensor PCB, Sensor Target, Target Holder, Knob, and Module Connection Cable, and the *ZMID4200 EVK Application Software* are designed for use only in a laboratory for evaluation purposes. The hardware and software must not be used for characterization measurements in terms of replacing calibrated laboratory environment and measurement devices. It must not be used with any setup where there is a risk of injury or death.

Important Safety Warning: These procedures can result in high currents, which can cause severe injury or death and/or equipment damage. Only trained professional staff should connect external equipment and operate the software.

Important Equipment Warning: Ensure the correct connection of all cables. Supplying the board using the wrong polarity could result in damage to the board and/or the equipment.

Contents

Figures

Tables

1. Introduction

This user manual describes the ZMID4200MROT36001 Rotary Application Module. This application module is designed to measure the rotary movement of a sensor target using the ZMID4200 Inductive Position Sensor IC, which is connected to an application specific coil design and located on the Rotary Application Module Sensor PCB.

For a first evaluation of the Application Module, the kit contains a target holder to locate and move the sensor target over the sensor coils. Using the separately available ZMID-COMBOARD, the Application Module can be connected to the user's computer. Using the *ZMID4200 EVK Application Software*, the module can be programmed and configured. To download the software and its user manual, visit the web page given on page 1.

After the first evaluation of the Application Module performance, the Rotary Application Module Sensor PCB and the sensor target can be mounted on any application for rapid prototyping. The design data of the Application Module is available (see section 1.1.3). The following sections describe technical details of the Application Module.

1.1 Module Description

The following tables provide the system, electrical, and mechanical parameters for the Application Module.

Note: For detailed information about the expected accuracy, refer to section 2.

Table 1. System Data

Symbol	Parameter	Conditions	Typical	Unit
TA_R	Angle Measurement Range		360	Degrees
TA_A	Target Angle		180	Degrees
COIL_L	RX Coil Range		360	Degrees
AG	Recommended Airgap between Coil and Target		1.5	mm
RES_DIG	Internal Digital Resolution		16	Bits
RES_OUT	Output Resolution	ZMID4200 Analog	10	Bits
		ZMID4200 PWM	10	Bits
		ZMID4200 SENT	12	Bits
F_S	Output Update Rate		10	kHz
T_A	Data Acquisition Time		50	µs

1.1.1. Electrical Data

For detailed information about the electrical data, refer to the *ZMID4200 Datasheet*.

Table 2. Electrical Data

Symbol	Parameter	Conditions	Typical	Unit
VDD	Supply Voltage		4.5 to 5.5	V
I_CC	Typical Current Consumption, No Load		12 to 21.5 (typical: 13)	mA
ZMID4200 Analog Output				
R_PUA	Output Pull-Up Resistor		3 to 10 (typical: 4.7)	kΩ
R_PDA	Output Pull-Down Resistor		3 to 10 (typical: 4.7)	kΩ
C_ANA	Output Capacitor for Analog		0.47 to 27	nF

Symbol	Parameter	Conditions	Typical	Unit
ZMID4200 PWM Output				
R_PUB		V_PU = 5V	1 to 10	kΩ
		V_PU = 16V	3 to 10	
C_PWM			1 to 20	nF
F_PWM	PWM Output Frequency Depending on Module Configuration		Programming options: 0.125, 0.25, 0.50, 0.75, 1.00, 1.25, 1.50, 2.00 (default)	kHz
	Normal Operating Range	Limits are programmable	5 to 95	% duty cycle
ZMID4200 SENT Output (see the *ZMID4200 Datasheet* regarding circuit options)				
R_01	SENT Output pi (π) Filter Resistor	Circuit option A, B, or C	120	Ω
C_11	SENT Output pi (π) Filter First Capacitor	Circuit option A, B, or C	2.2	nF
T_TICK	Clock Tick Time		3.0 to 3.67	µs
C_12	SENT Output pi (π) Filter, Second Capacitor	Circuit option C	2.2	nF
		Circuit option A or B	3.9	nF

1.1.2. Electrical Connections to interfacing an Application MCU

If the Application Module is connected to an application host MCU, additional components might be required. The connection diagrams and additional components required for the different output interface options are found in the *ZMID4200 Datasheet.*

1.1.3. Design Documentation

The design data are available on the webpage (see page 1), or they can be requested from (see contact information on the last page). The support package contains the design files as well as the fabrication outputs for the ZMID4200MROT36001 Rotary Application Module including the following:

- 3-D data (*.step*)
- Fabrication outputs (Gerber)
- PCB design files (Altium)
- Mechanical dimensions (*.dxf)*

1.2 Getting Started

1.2.1. Module Hardware Connections

Follow these procedures to set up the kit as shown in Figure 1:

1. Connect the Application Module to a ZMID-COMBOARD or to an external application using the sensor cable using the connectors shown in Figure 1. See Table 3 for the details for the connectors.
2. If using the ZMID-COMBOARD, connect it to the user's computer using a USB cable or power up the user's application controller.

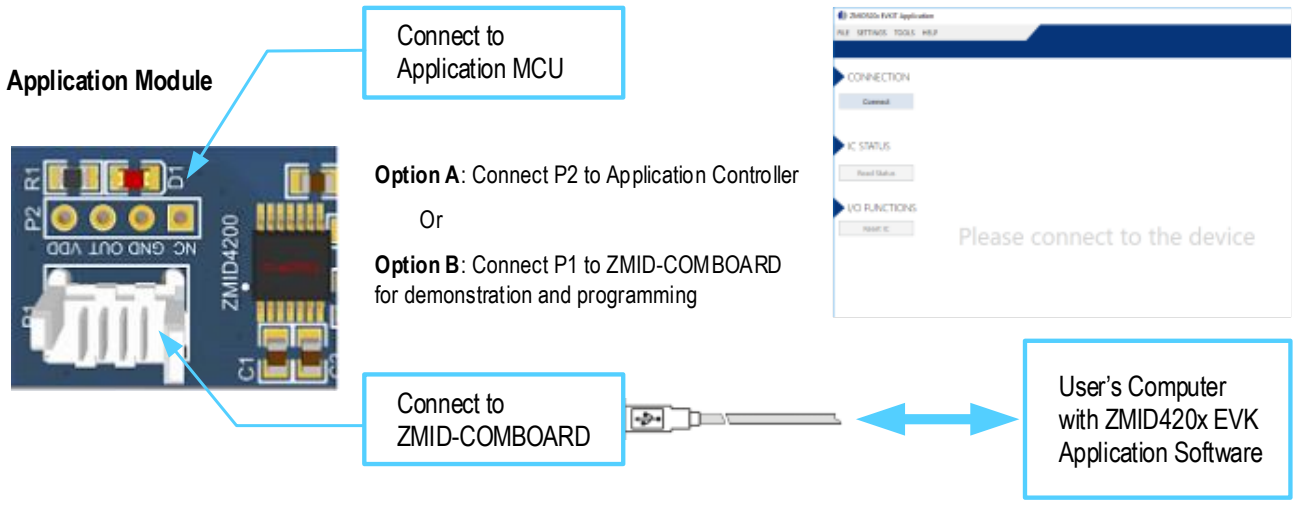
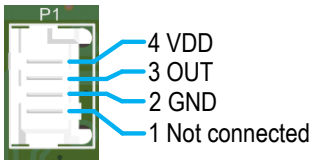
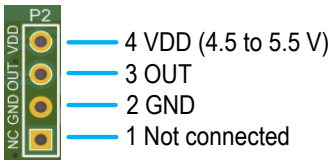


Figure 1. Application Module Connections

Table 3. Evaluation Kit Connection Descriptions

Connector	Type	Description	
P1	4-Pin Molex Picoflex	Header to connect the Application Module to the ZMID-COMBOARD	
P2	4-Pin Header	Header to connect the Application Module to an existing application	

1.2.2. Target Holder Assembly Instructions

The target holder is assembled as shown below.

1. Place the rotation axis on the Rotary Application Module Sensor PCB.
2. Mount the target on the rotation axis.
3. Place the target holder within the angular limits on the inductive sensor PCB and rotation axis.
4. Mount the knob on the rotation axis.

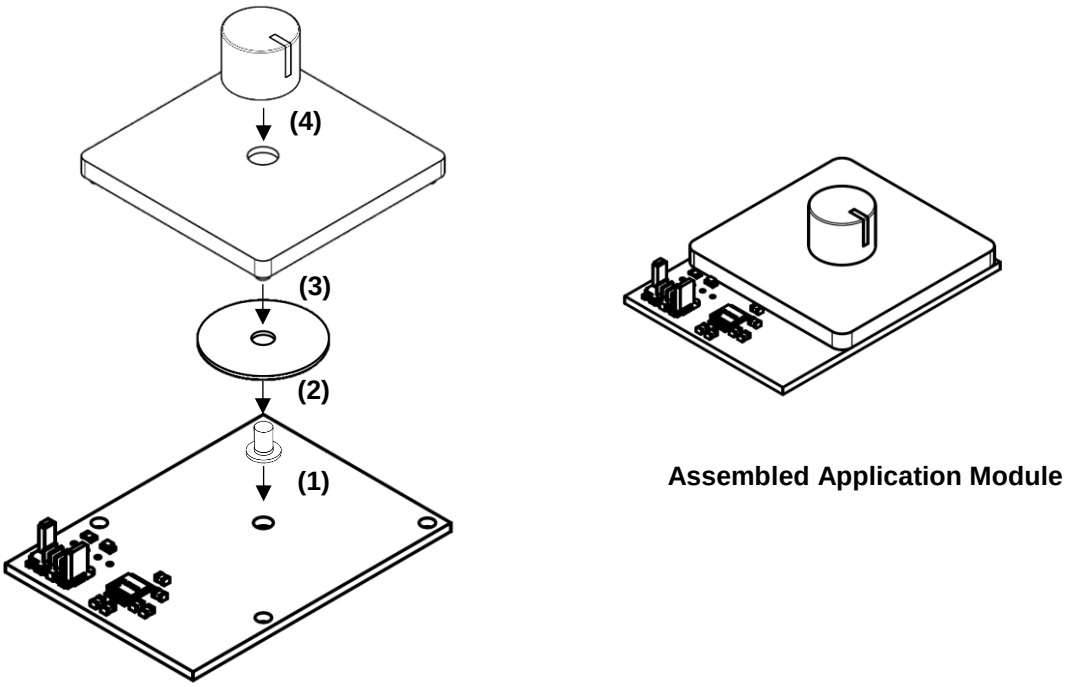


Figure 2. Target Holder Assembly

1.2.3. Sensor Configuration and Calibration

The application module is preconfigured for the mechanical configuration when using the target holder. If the Rotary Application Module Sensor PCB is mounted on any existing application with a mechanical configuration different from the application module mechanics, the sensor IC must be configured and programmed for the new setup. This can be done using the ZMID-COMBOARD and the *ZMID4200 EVK Application Software*.

2. Application Measurement

The application module was measured to assess the typical sensing performance. For positioning the target at different positions and displacements relative to the center axis, a four axis measurement table was used. At each displacement position, the digital output value was read to obtain the data shown in the graphs in section 2.1. In the graphs that show the effects of displacement, the X direction is right/left displacement parallel to the board surface as oriented in the figure on page 1 and the Y direction is displacement perpendicular to the X axis and parallel to the board surface.

The graphs show the effects of differences in the airgap, which is the distance between the sensor coils and the target surface.

2.1 Output Measurement at 1.5mm Airgap

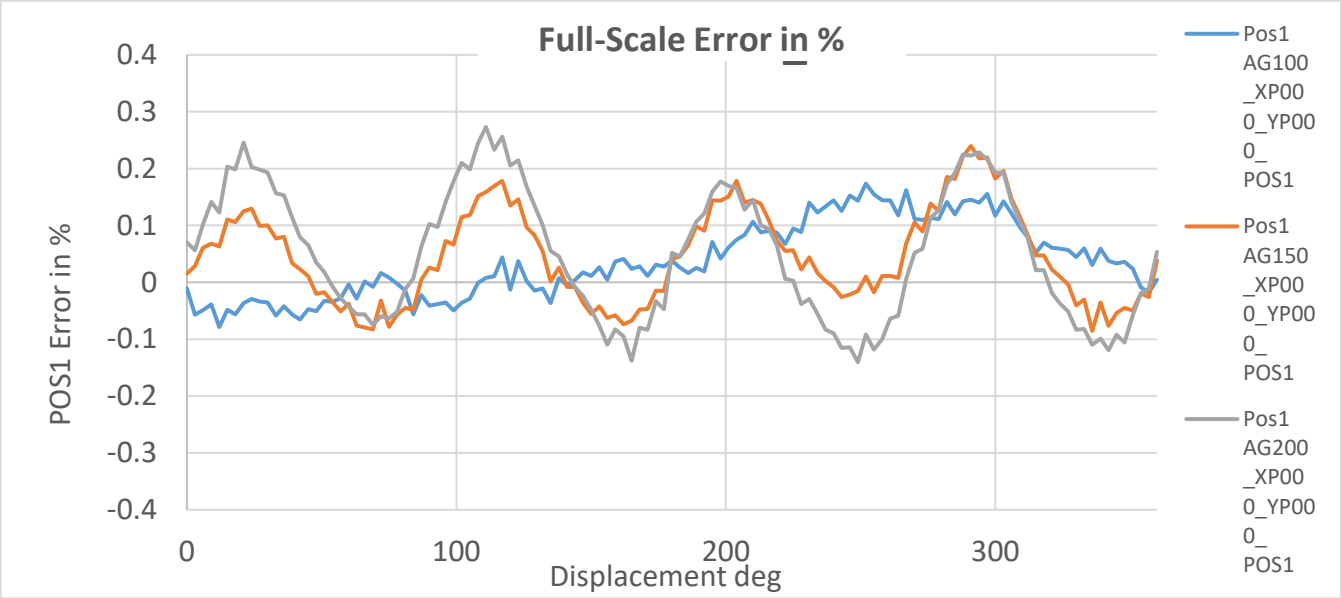
For this measurement, the sensor was calibrated at an airgap of 1.5mm. The sensor gain, offset, and slope were configured for the measurement range, and the output was linearized.

Table 4. Sensor Configuration for the Measurement

Name	Offset	Slope	Clamping	LinInt0	LinInt1	LinInt2	LinInt3
Register	00_{HEX}	01_{HEX}	02_{HEX}	03_{HEX}	04_{HEX}	05_{HEX}	06_{HEX}

Value	17C0	0400	0000	8200	8481	8500	8683
Name	**LinInt4**	**CoilOffset**	**CalMode**	**Trimming**	**AGC0**	**AGC1**	**Mask**
Register	07_{HEX}	08_{HEX}	09_{HEX}	$0B_{HEX}$	$0C_{HEX}$	$0D_{HEX}$	$0E_{HEX}$
Value	0080	1000	1100	B103	0838	0055	BFFF
Name	**Trace0**	**Trace1**	**Misc**				
Register	$0F_{HEX}$	10_{HEX}	11_{HEX}				
Value	0000	0000	00C2				

Figure 3. Accuracy with Linearization at 1.5mm Airgap (AG150)



Note: AG100 = 1mm airgap; AG150 = 1.5mm; and AG200 = 2.0mm airgap.

Figure 4. Accuracy with Linearization at 1.5mm Airgap and Effects of Airgap Changes

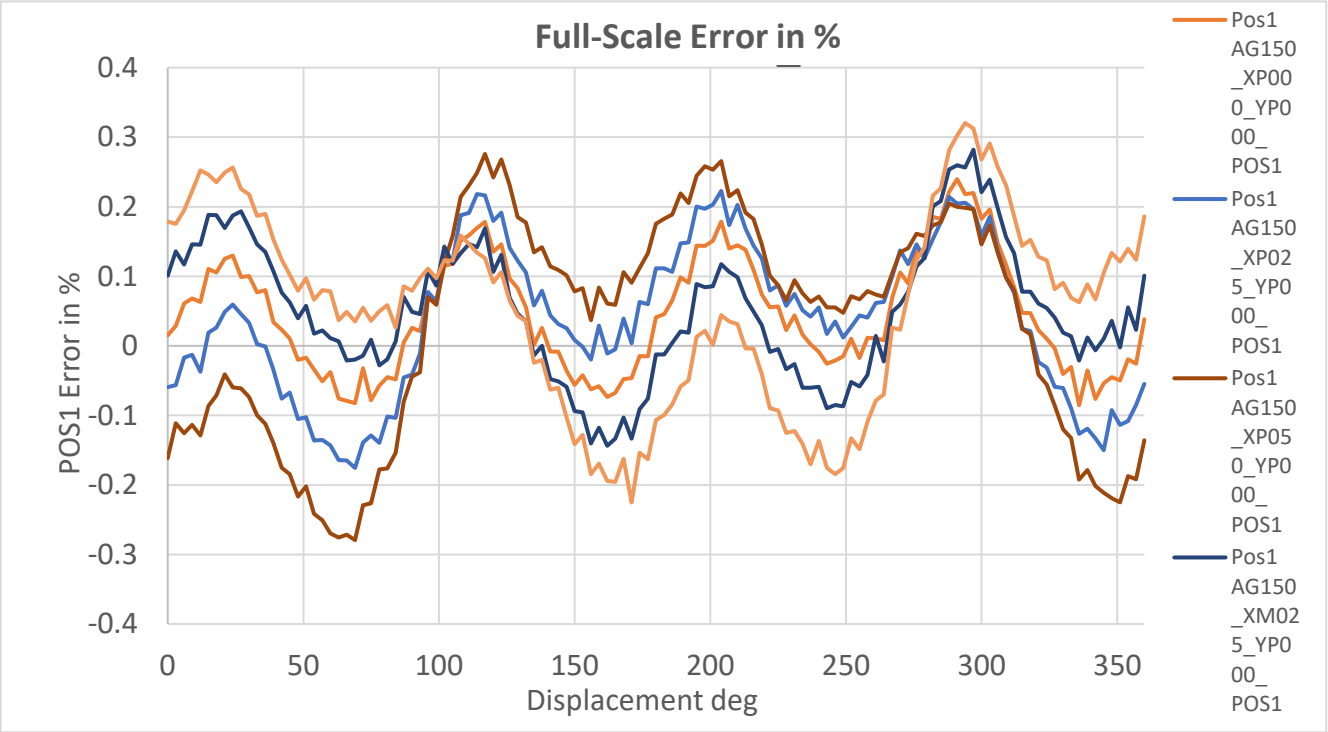


Figure 5. Accuracy with Linearization at 1.5mm Airgap and Effects of Displacement in X

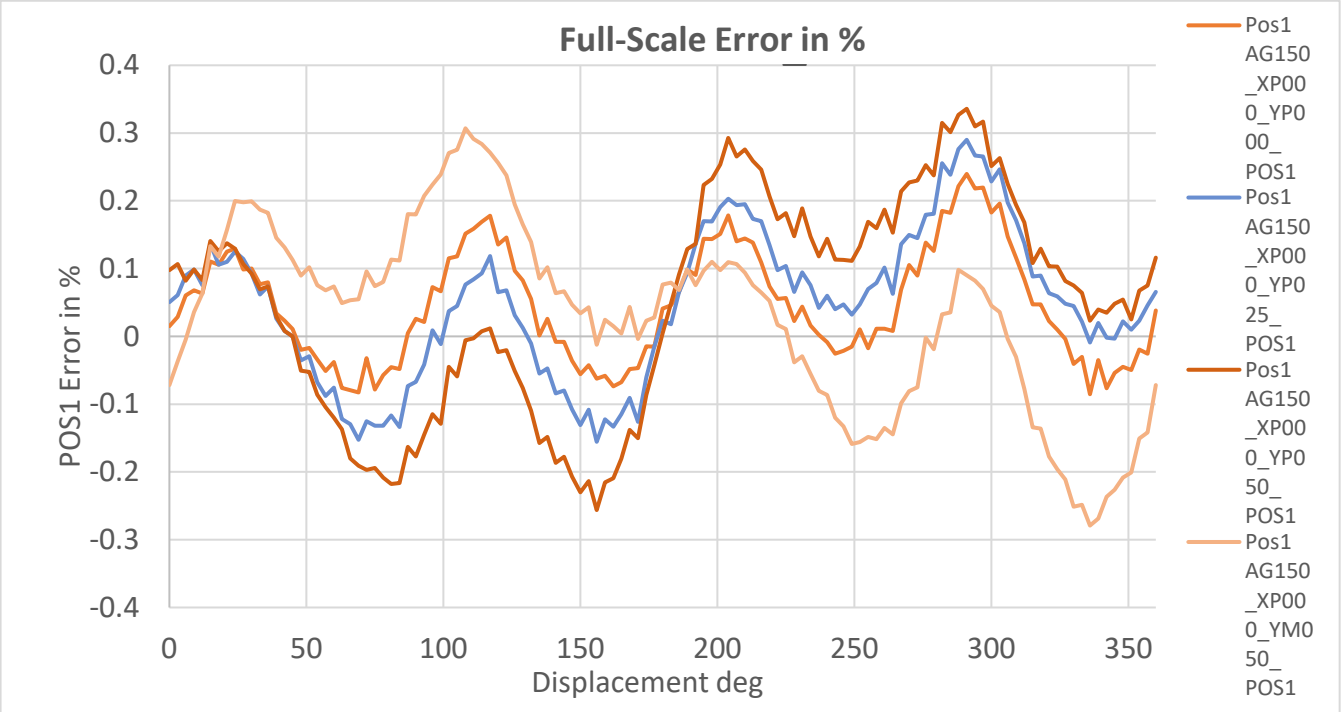
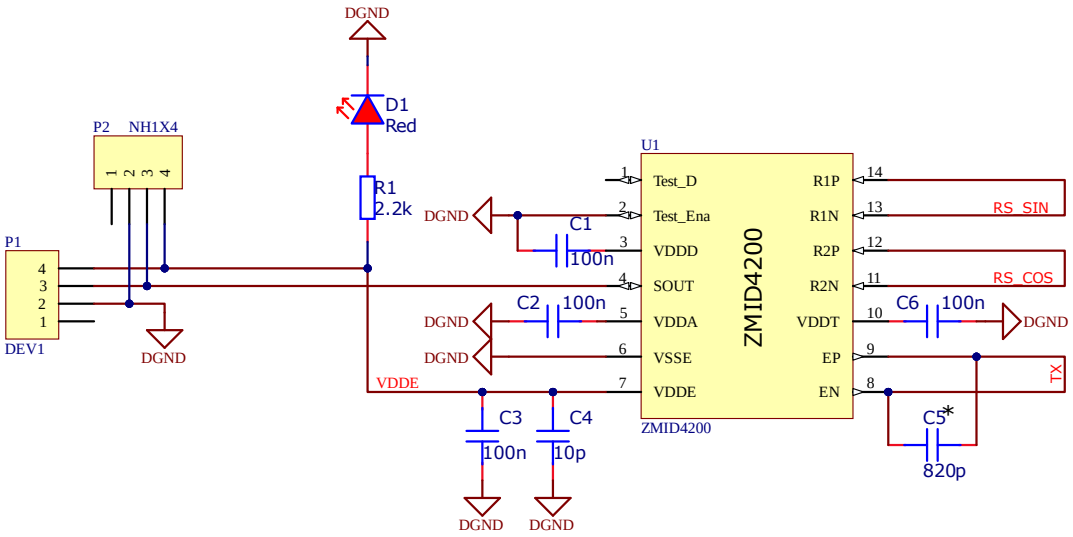


Figure 6. Accuracy with Linearization at 1.5mm Airgap and Effects of Displacement in Y

3. Rotary Application Module Sensor PCB

3.1 Schematic

The Rotary Application Module Sensor PCB schematic is shown below. The board contains the ZMID4200 contactless inductive position sensor as well as the headers, power LED, and required capacitors for the integrated voltage regulator and the integrated oscillator. Also take into consideration any components required on the receiver side depending on the output type for the ZMID4200.

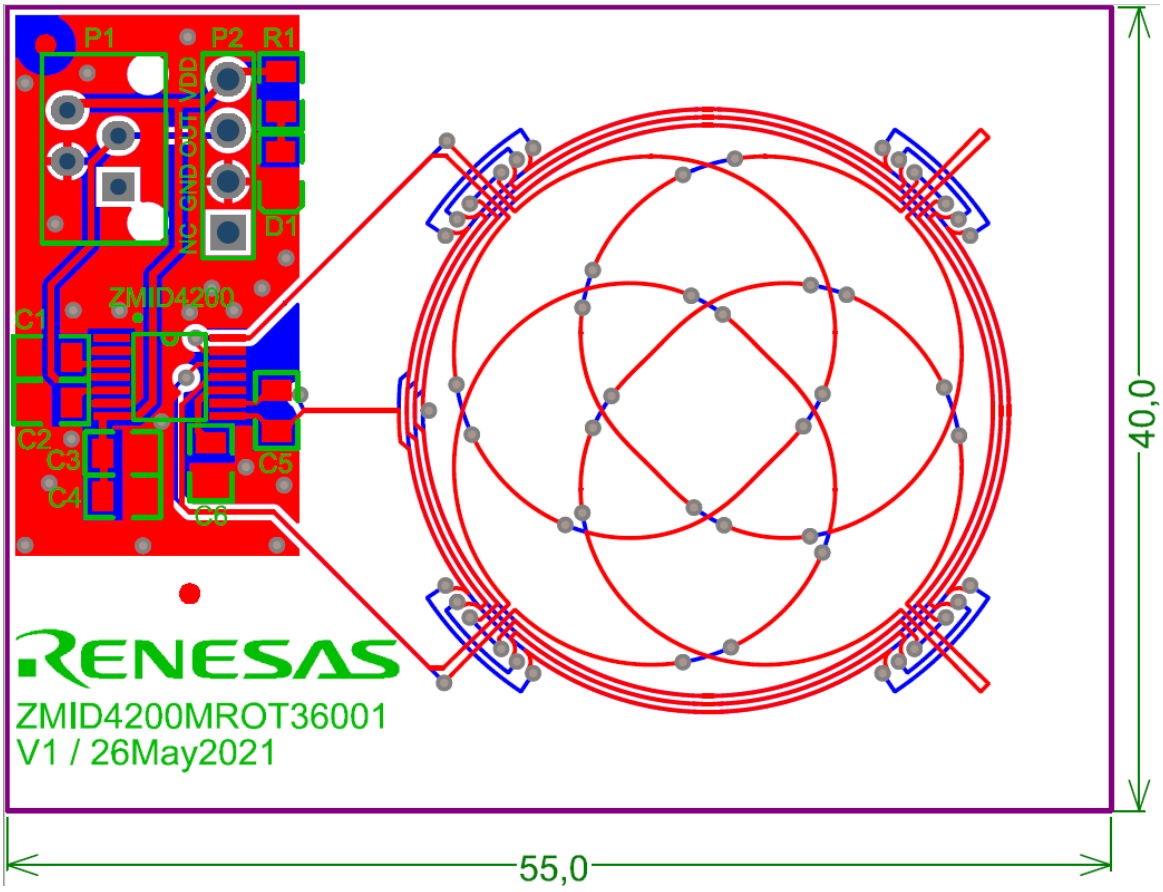


Note: C5* needs to be calculated in base of TX inductance.

Figure 7. Rotary Application Module Sensor PCB Schematic

3.2 Layout

For an appropriate coil design, specific tools to generate the coil pattern were used. These tools are available to Renesas customers if custom coil designs are needed.



Note: Dimensions are in mm.

Figure 8. Rotary Application Module Sensor PCB Layout and Dimensions

3.3 Bill of Materials (BOM)

Table 5. Rotary Application Module Sensor PCB BOM

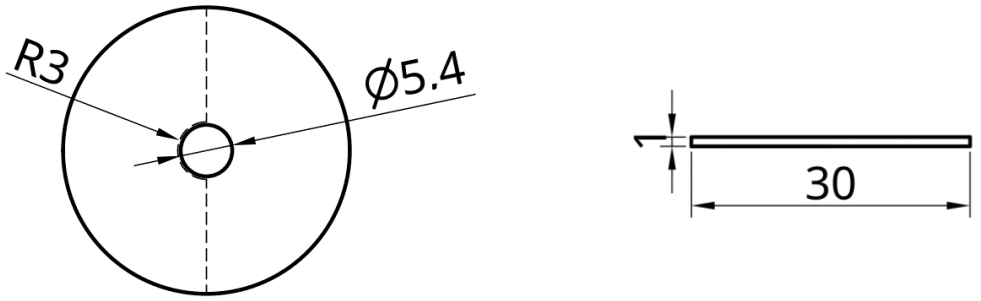
DNP = Do not populate.

Designator	Value	Package	Manufacturer P/N	Manufacturer	Quantity
U1	ZMID4200	TSSOP-14	(Refer to the ZMID4200 Datasheet)	Renesas	1
C1, C2, C3, C4	100nF	0805	CL21B104KCFSFNG	Comet	4
C5	10pF	0805	CL21C100DBNC	Comet	1
C6, C7 (DNP), C8 (DNP)	820pF	0805	CGA4F2COG2A222J085AA	Comet	3
D1	LED Red	0805	OSR50805C1E	Comet	1
P1	Header	NH1X4	HN1X4	Comet	1
P2	Header	Molex Picoflex 4-pin	90325-0004	Farnell	1
R1	2kΩ	0805	R0805 2.0K 1%	Comet	1

4. Mechanical Components

The Application Module is shipped together with a target holder which is used to move the target over the receiver coil for evaluation purposes. A description of the target holder mechanics is shown below.

4.1 Sensor Target

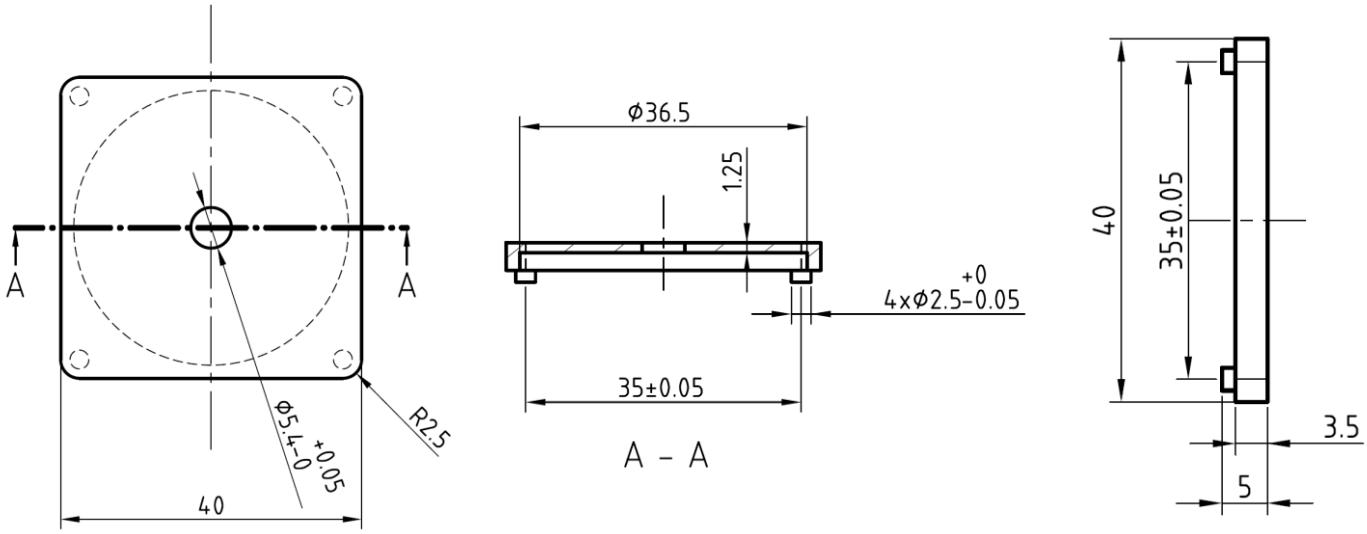


Note: Dimensions are in mm.

Figure 9. Sensor Target Dimensions

4.2 Target Holder

The target holder allows rotary movement of the sensor target at an airgap of 1mm. The target knob is used as well to define the start and stop position of the travel.

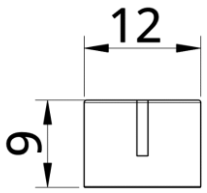


Note: Dimensions are in mm.

Figure 10. Sensor Target Holder Dimensions

4.3 Target Holder Knob

The target knob is used to slide the target inside the target holder.



Note: Dimensions are in mm.

Figure 11. Sensor Target Knob Dimensions

5. Ordering Information

Orderable Part Number	Description
ZMID4200MROT36001	Inductive Rotary Application Module with 360° Measurement including Rotary Application Module Sensor PCB, Sensor Target, Target Holder, Rotation Axis, Knob, Module Connection Cable

6. Revision History

Revision	Date	Description
1.0	Jul 21, 2021	Initial release.

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.

(Disclaimer Rev.5.0-1 October 2020)

Corporate Headquarters

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

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/

Trademarks

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