

## ZMID4200MARC13001

### Arc 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.

The ZMID4200MARC36001 Arc Application Module demonstrates inductive arc position sensing. The Application Module can be programmed for a specific application range using Renesas' ZMID-COMBOARD, which is separately available.

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

### Kit Contents

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

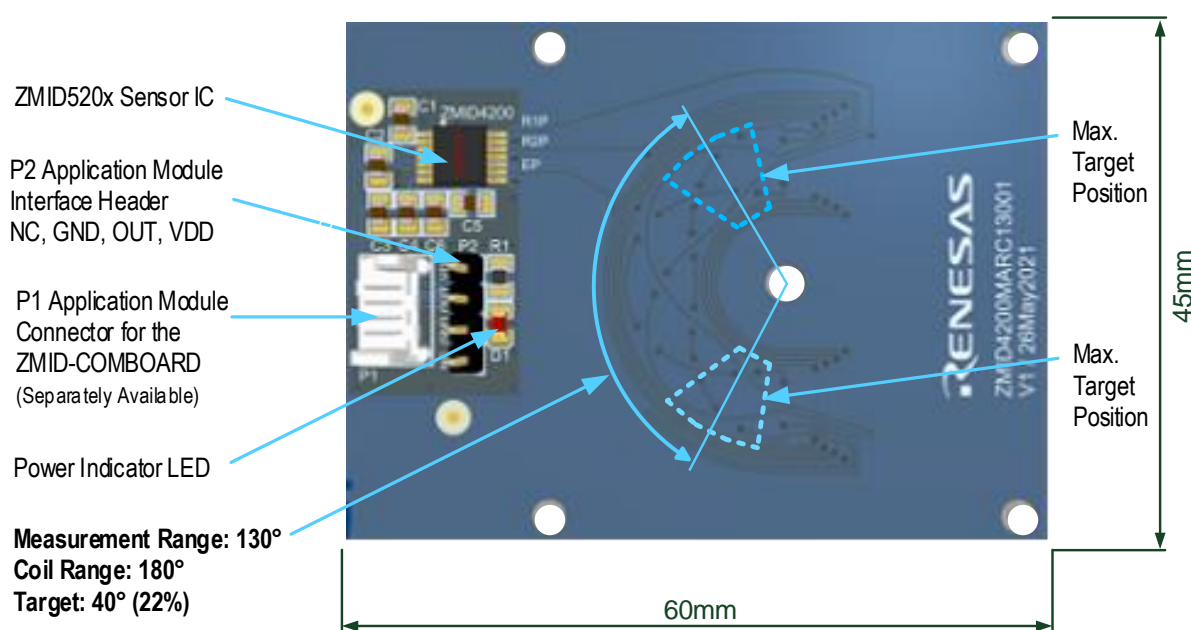
### Features

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

### Arc Module Summary

- Measurement range 130° (using a 22% target)
- Output resolution
  - 10-bit Analog Output = 0.13°
  - 10-bit PWM Output = 0.13°
  - 12-bit SENT Output = 0.03°

## ZMID4200MARC13001 Arc Application Module Sensor PCB



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Renesas' ZMID4200MARC36001 Arc Application Module, consisting of the Arc 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**

<b>1. Introduction</b>	<b>4</b>
1.1 Module Description	4
1.1.1. Electrical Data	4
1.1.2. Electrical Connections for Interfacing with an Application MCU	5
1.1.3. Design Documentation	5
1.2 Getting Started	5
1.2.1. Module Hardware Connections	5
1.2.2. Target Holder Assembly Instructions	6

1.2.3.	Sensor Configuration and Calibration .....	7
<b>2.</b>	<b>Application Measurement .....</b>	<b>7</b>
2.1	Output Measurement with a 1.5mm Airgap .....	7
<b>3.</b>	<b>Arc Application Module Sensor PCB.....</b>	<b>9</b>
3.1	Schematic .....	9
3.2	Layout .....	10
3.3	Bill of Materials (BOM).....	10
<b>4.</b>	<b>Mechanical Components .....</b>	<b>11</b>
4.1	Sensor Target .....	11
4.2	Target Holder .....	11
4.3	Target Holder Knob .....	12
<b>5.</b>	<b>Ordering Information.....</b>	<b>12</b>
<b>6.</b>	<b>Revision History .....</b>	<b>12</b>

## Figures

Figure 1.	Application Module Connections .....	6
Figure 2.	Target Holder Assembly .....	7
Figure 3.	Sensor Configuration for the Measurement .....	7
Figure 4.	Accuracy with Linearization at 1.5mm Airgap (AG150).....	8
Figure 5.	Accuracy with Linearization at 1.5mm Airgap (AG150) and Effects of Airgap Changes .....	8
Figure 6.	Accuracy with Linearization at 1.5mm Airgap and Effects of Displacement in X .....	8
Figure 7.	Accuracy with Linearization at 1.5mm Airgap and Effects of Displacement in Y .....	9
Figure 8.	Arc Application Module Sensor PCB Schematic.....	9
Figure 9.	Arc Application Module Sensor PCB Layout and Dimensions .....	10
Figure 10.	Sensor Target Dimensions .....	11
Figure 11.	Sensor Target Holder Dimensions .....	11
Figure 12.	Sensor Target Knob Dimensions .....	12

## Tables

Table 1.	System Data .....	4
Table 2.	Electrical Data.....	4
Table 3.	Evaluation Kit Connection Descriptions.....	6
Table 4.	Arc Application Module Sensor PCB BOM.....	10

# 1. Introduction

This user manual describes the ZMID4200MARC13001 Arc Application Module. This application module is designed to measure the arc 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 Arc 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. The Application Module can be connected to the user's computer using the separately available ZMID-COMBOARD. The module can be programmed and configured using the *ZMID4200 EVK Application Software*, which is available on the web page given on page 1.

After the first evaluation of the Application Module performance, the Arc Application Module Sensor PCB and the sensor target can be mounted on any application for rapid prototyping. The design data for the Application Module is available on-line (see section 1.1.3). The following sections describe the 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
TR	Arc Measurement Range <sup>1</sup>		130	Degrees
TA_A	Target Angle <sup>1</sup>		40	Degrees
COIL_L	RX Coil Range		180	Degrees
AG	Recommended airgap between coil and target		1.5	mm
RES_DIG	Internal Digital Resolution		16	Bit
RES_OUT	Output Resolution	Analog	10	Bits
		PWM	10	Bits
		SENT	12	Bits
T_R	Output Update Rate		10	kHz
T_A	Data Acquisition Time		50	μs

1. The Arc Application Module Sensor PCB can also be used with a smaller width target. Using a smaller target will increase the measurement range.

### 1.1.1. Electrical Data

For detailed information about the electrical data, refer to the *ZMID4200 Datasheet*. See the connection diagrams in section 1.2.

**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
<b>ZMID4200 Analog Output</b>				
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

Symbol	Parameter	Conditions	Typical	Unit
C_ANA	Output Capacitor for Analog		0.47 to 27	nF
<b>ZMID4200 PWM Output</b>				
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		Programmin g 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
<b>ZMID4200 SENT Output (see the ZMID4200 Datasheet regarding circuit options)</b>				
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 for Interfacing with 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 Renesas webpage (see page 1). They can be also requested from Renesas (see contact information on the last page). The support package contains the design files as well as the fabrication outputs for the ZMID4200MARC13001 Arc Application Module including the following:

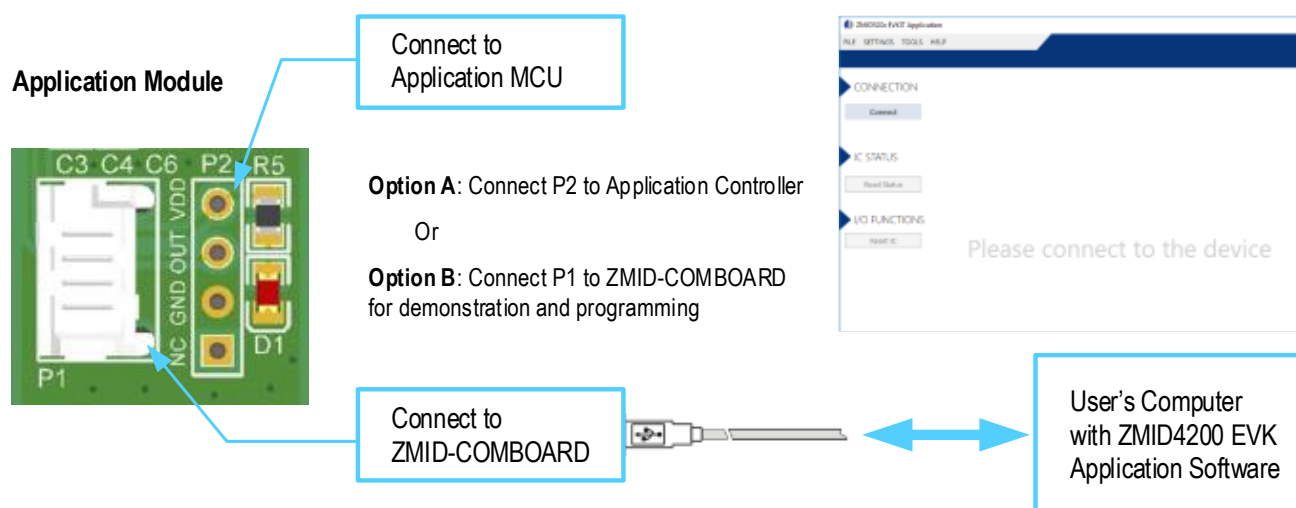
- 3-D data (.step)
- Fabrication outputs (Gerber)
- PCB design files (Altium)
- Mechanical dimensions (.dxf)

## 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 via 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 Arc 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.

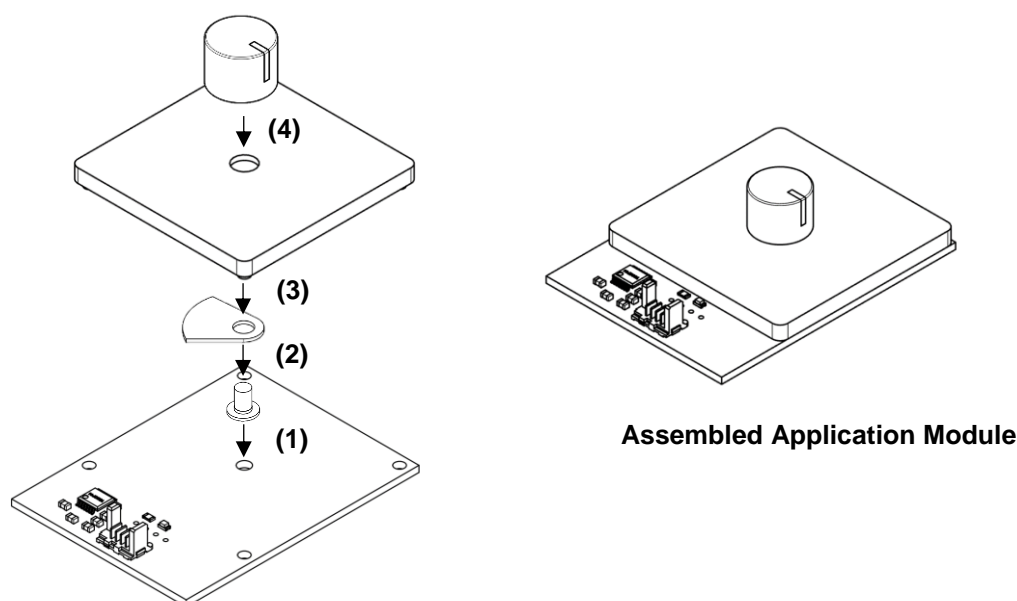


Figure 2. Target Holder Assembly

### 1.2.3. Sensor Configuration and Calibration

The Application Module is preconfigured for the mechanical configuration when using the target holder. If the Arc 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 airgap referred to in section 2.1 is the distance between the sensor coils and the target surface.

### 2.1 Output Measurement with a 1.5mm Airgap

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

Figure 3. Sensor Configuration for the Measurement

Name	Offset	Slope	Clamping	LinInt0	LinInt1	LinInt2	LinInt3
Register	0x00	0x01	0x02	0x03	0x04	0x05	0x06
Value	22CF	05B1	0000	0300	090D	A18F	919C
Name	LinInt4	CoilOffset	CalMode	Trimming	AGC0	AGC1	Mask
Register	0x07	0x08	0x09	0x0b	0x0c	0x0d	0x0e
Value	0080	00AC	010D	B107	083B	0055	BFFF
Name	Trace0	Trace1	Misc				
Register	0x0f	0x10	0x11				
Value	0000	0000	00C2				

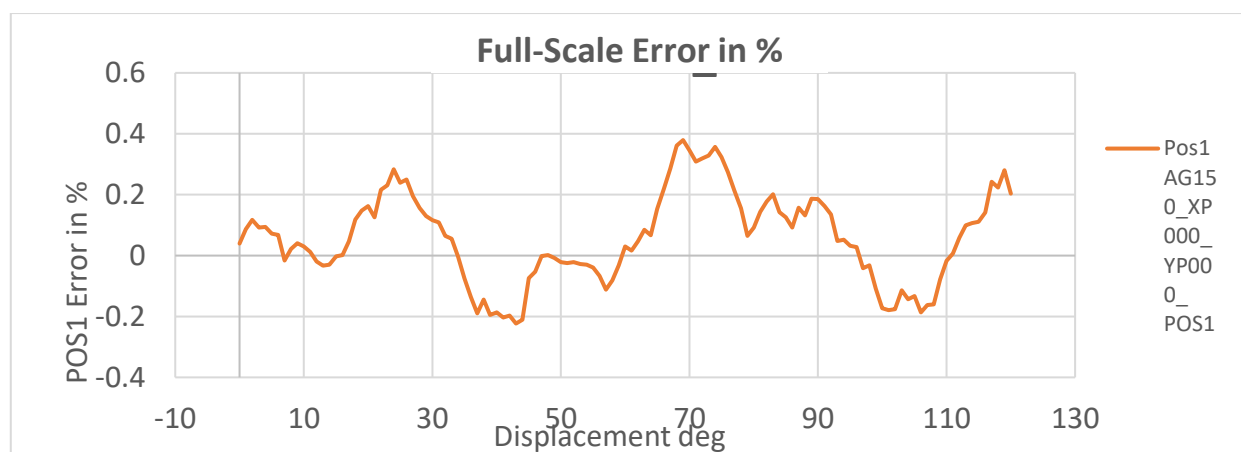
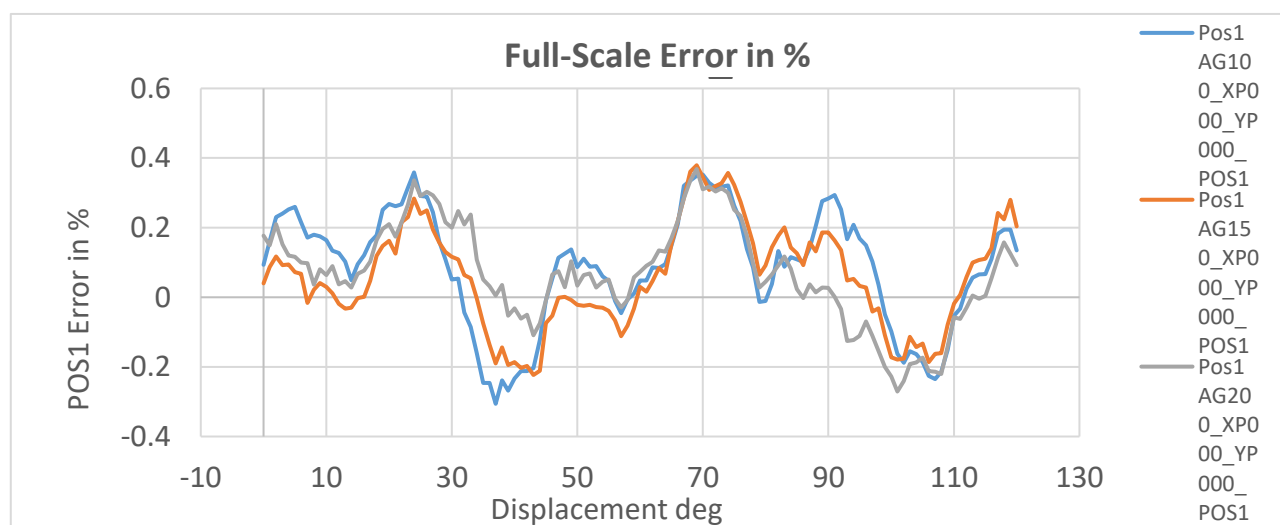


Figure 4. Accuracy with Linearization at 1.5mm Airgap (AG150)



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

Figure 5. Accuracy with Linearization at 1.5mm Airgap (AG150) and Effects of Airgap Changes

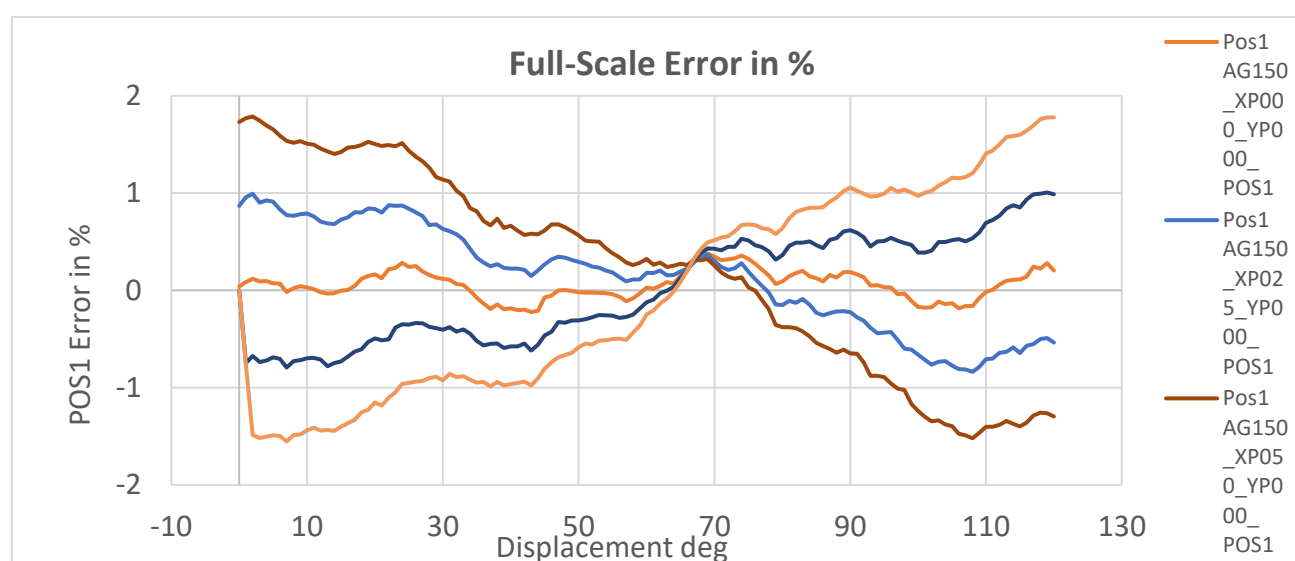


Figure 6. Accuracy with Linearization at 1.5mm Airgap and Effects of Displacement in X



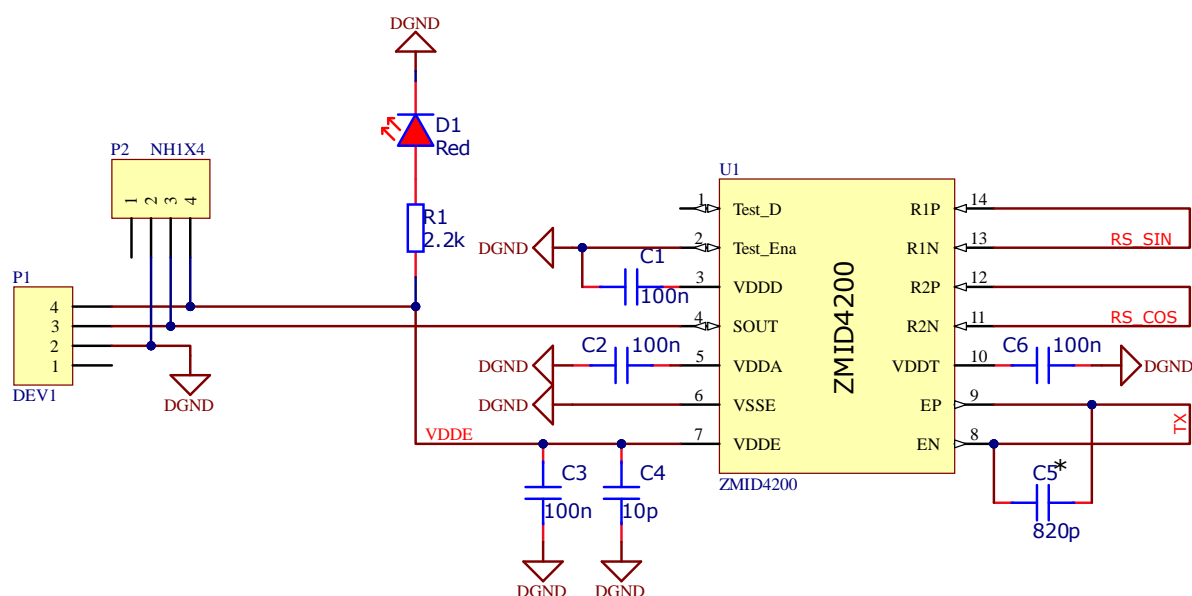


Figure 7. Accuracy with Linearization at 1.5mm Airgap and Effects of Displacement in Y

### 3. Arc Application Module Sensor PCB

#### 3.1 Schematic

The Arc Application Module Sensor PCB schematic is shown below. It 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 at the receiver side depending on the selected output variant.

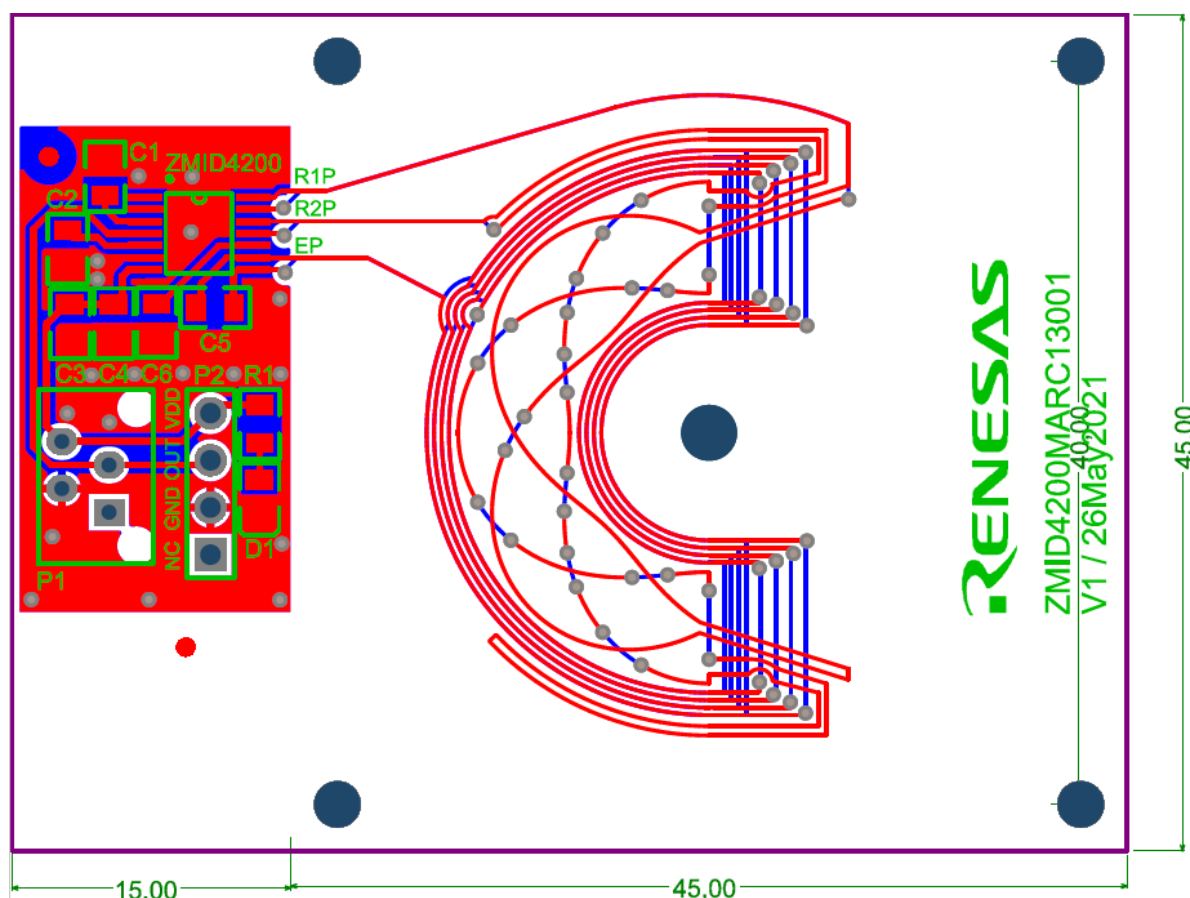


Note: C5\* needs to be calculated in base of TX inductance.

Figure 8. Arc Application Module Sensor PCB Schematic

### 3.2 Layout

The Arc Application Module Sensor PCB layout is shown in Figure 9. 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 9. Arc Application Module Sensor PCB Layout and Dimensions

### 3.3 Bill of Materials (BOM)

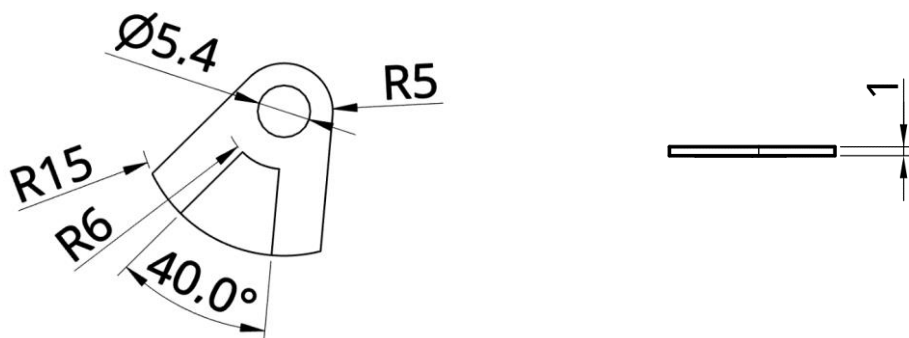
Table 4. Arc Application Module Sensor PCB BOM

Designator	Value	Package	Manufacturer P/N	Manufacturer	Quantity
U1	ZMID4200	TSSOP-14	(Refer to the <i>ZMID4200 Datasheet</i> )	Renesas	1
C1, C2, C3, C6	100nF	0805	CL21B104KCF5FNG	Comet	4
C4	10pF	0805	CL21C100DBNC	Comet	1
C5	820pF	0805	CGA4F2COG2A222J085AA	Comet	1
D1	LED Red	0805	OSR50805C1E	Comet	1
P2	Header	NH1X4	HN1X4	Comet	1
P1	Header	Molex Picoflex 4-pin	90325-0004	Farnell	1
R5	2kΩ	0805	R0805 2.0K 1%	Comet	1

## 4. Mechanical Components

The application module is shipped 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

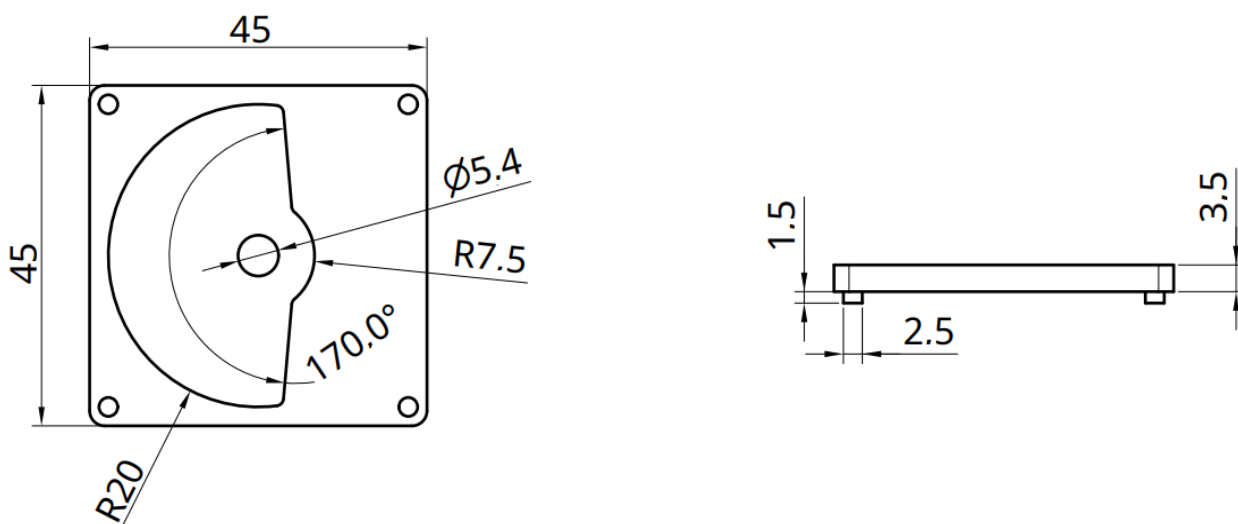


Note: Dimensions are in mm.

Figure 10. Sensor Target Dimensions

### 4.2 Target Holder

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

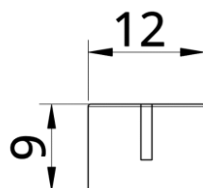


Note: Dimensions are in mm.

Figure 11. 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 12. Sensor Target Knob Dimensions

## 5. Ordering Information

Orderable Part Number	Description
ZMID4200MARC13001	Inductive Arc Application Module with 130° Measurement Range including Arc Application Module Sensor PCB, Sensor Target, Target Holder, Rotation Axis, Knob, Module Connection Cable
ZMID-COMBOARD	USB Communication and Programming Interface for ZMID Inductive Application Modules, Micro-USB Cable

## 6. Revision History

Revision	Date	Description
1.0	Jul 21, 2021	Initial release.

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TOYOSU FORESIA, 3-2-24 Toyosu,  
Koto-ku, Tokyo 135-0061, Japan  
[www.renesas.com](http://www.renesas.com)

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