

RAA3064002GFP/RAA3064003GFP

Guide to Selecting Peripheral Components for Use with the Resolver-to-Digital Converters

Summary

This application note describes constants (or values) and settings required of external components to be used with the RAA3064002GFP or RAA3064003GFP resolver-to-digital converter IC.

Target Devices

RAA3064002GFP and RAA3064003GFP

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1. Overview

Figure 1.1 and figure 1.2 show examples of system configurations of the RAA3064002GFP and RAA3064003GFP. For the peripheral circuits, see section 2, Selecting Peripheral Components.

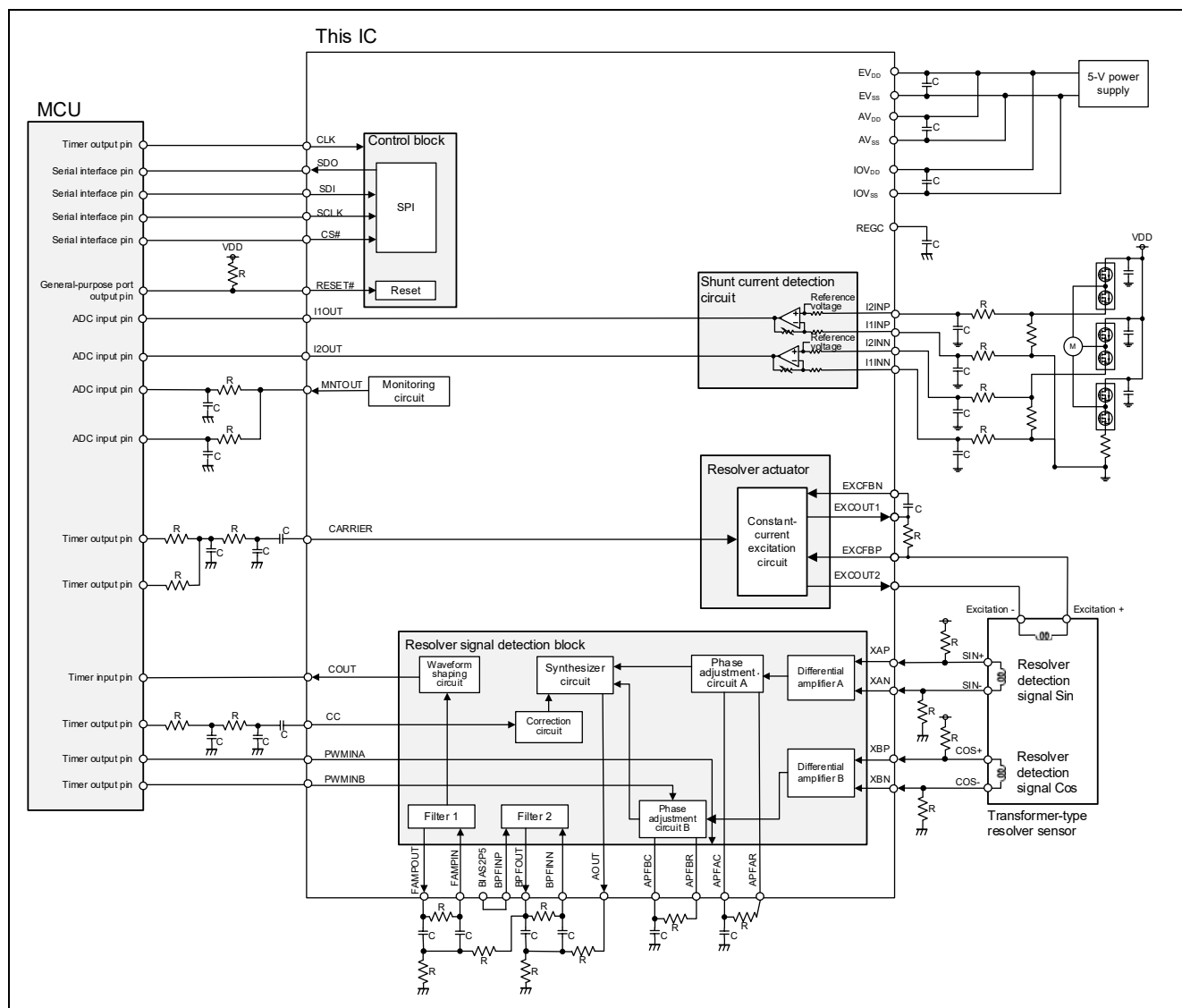


Figure 1.1 Example of a System Configuration with a Transformer-Type Resolver Sensor and Multiple-Feedback First-Order Band-Pass Filters 1 and 2

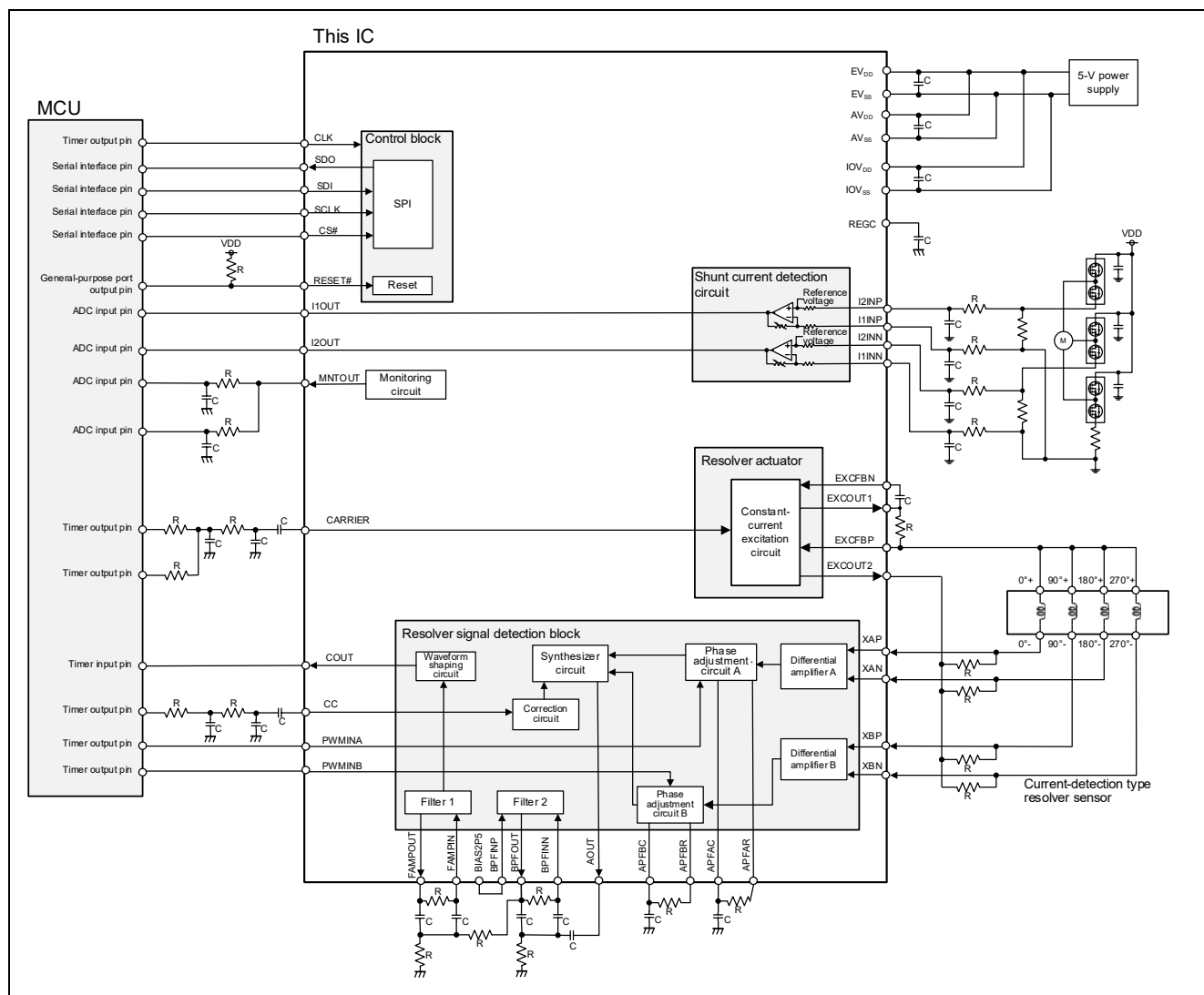


Figure 1.2 Example of the System Configuration with a Current-Detection Type Resolver Sensor, Multiple Feedback Second-Order High-Pass Filter 1, and Multiple-Feedback First-Order Band-Pass Filter 2

2. Selecting Peripheral Components

This section describes the configuration of the peripheral circuits of the RAA3064002GFP and RAA3064003GFP, and the selection of constants or values.

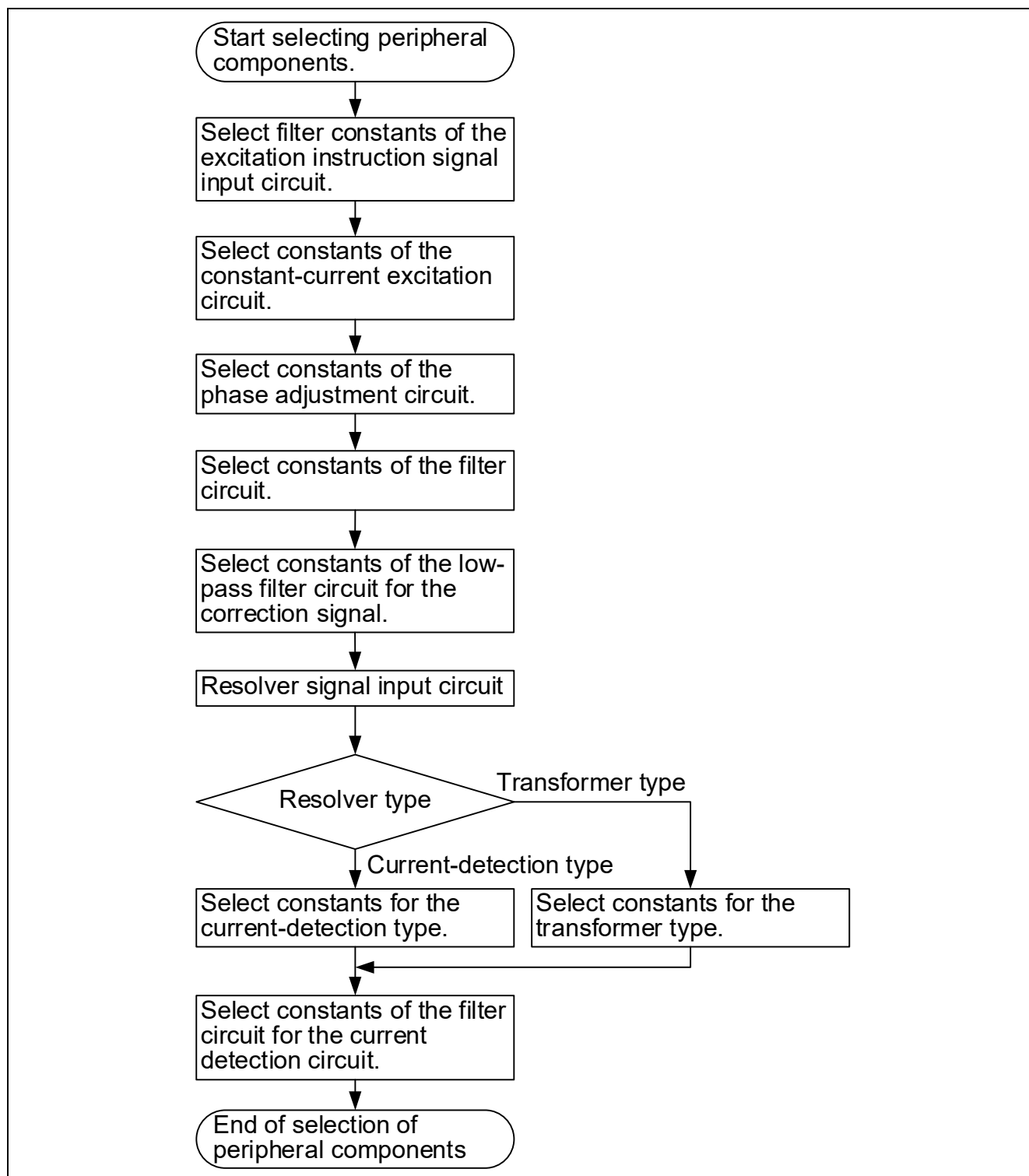


Figure 2.1 Flow of Selecting Peripheral Components

2.1 Circuit for the Input of the Resolver Actuating Signal

The resolver actuating signal is output from an MCU to the CARRIER pin of the RAA3064002GFP or RAA3064003GFP. This signal consists of two rectangular waveforms output from the timers in the MCU. The external filter circuit synthesizes a signal similar to a sine wave from these waveforms. This signal is then input to the CARRIER pin. Figure 2.2 shows an example of the circuit for the input of the resolver actuating signal. Table 2.1 lists typical filter constants. Adjust the filter constants to suit the excitation frequency.

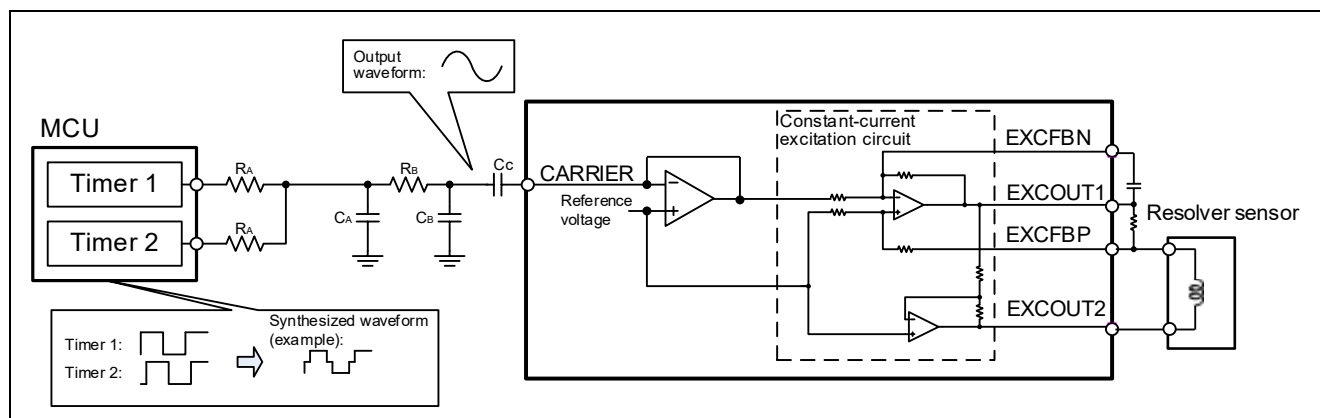


Figure 2.2 Example of the Circuit for the Input of the Resolver Actuating Signal

Table 2.1 Example of the Constants of the Circuit for the Input of the Resolver Actuating Signal

Excitation Frequency	Component	Number	Value	Tolerance	Temperature Characteristics
5 kHz	Resistor	RA	3.9 kΩ	±1%	±100 ppm/°C
	Resistor	RB	20 kΩ	±1%	±100 ppm/°C
	Capacitor	CA	15 nF	±5%	±30 ppm/°C
	Capacitor	CB	1.5 nF	±5%	±30 ppm/°C
	Capacitor	CC	0.01 μF	±10%	±15 ppm/°C
10 kHz	Resistor	RA	3.0 kΩ	±1%	±100 ppm/°C
	Resistor	RB	15 kΩ	±1%	±100 ppm/°C
	Capacitor	CA	10 nF	±5%	±30 ppm/°C
	Capacitor	CB	1 nF	±5%	±30 ppm/°C
	Capacitor	CC	0.01 μF	±10%	±15 ppm/°C
20 kHz	Resistor	RA	3.9 kΩ	±1%	±100 ppm/°C
	Resistor	RB	20 kΩ	±1%	±100 ppm/°C
	Capacitor	CA	3.3 nF	±5%	±30 ppm/°C
	Capacitor	CB	330 pF	±5%	±30 ppm/°C
	Capacitor	CC	0.01 μF	±10%	±15 ppm/°C

2.2 Resolver Actuator

The RAA3064002GFP and RAA3064003GFP each incorporate a constant-current excitation circuit to apply the excitation current for the resolver. Figure 2.3 shows an example of connections between the constant-current excitation circuit and a resolver sensor. The constant-current excitation circuit requires a feedback capacitor C_A and a current limiting resistor R_A . They must be placed near the IC. Connect components with values that are appropriate for the excitation frequency. Table 2.2 lists typical values for the constant-current excitation circuit.

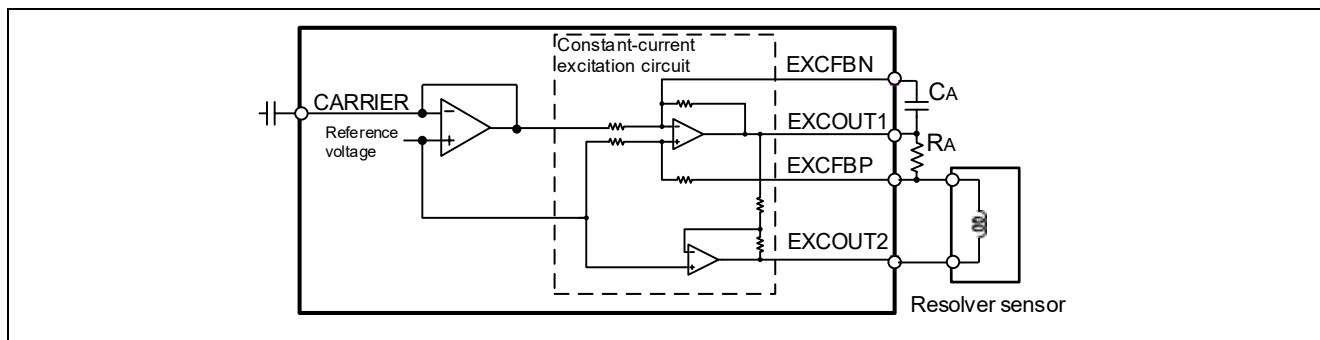


Figure 2.3 Constant-Current Excitation Circuit

Table 2.2 Example of Constants of the Constant-Current Excitation Circuit

Excitation Frequency	Component	Number	Value	Tolerance	Temperature Characteristics
5 kHz	Resistor	R_A	4.7 Ω	$\pm 5\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	2.7 nF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$
10 kHz	Resistor	R_A	5.1 Ω	$\pm 5\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	1.5 nF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$
20 kHz	Resistor	R_A	4.7 Ω	$\pm 5\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	680 pF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$

2.3 Phase Adjustment Circuit

The RAA3064002GFP and RAA3064003GFP each incorporate two phase adjustment circuits. Each phase adjustment circuit requires an external capacitor and resistor. Select them to suit the excitation frequency.

Figure 2.4 shows the phase adjustment circuits and Table 2.3 lists typical constants.

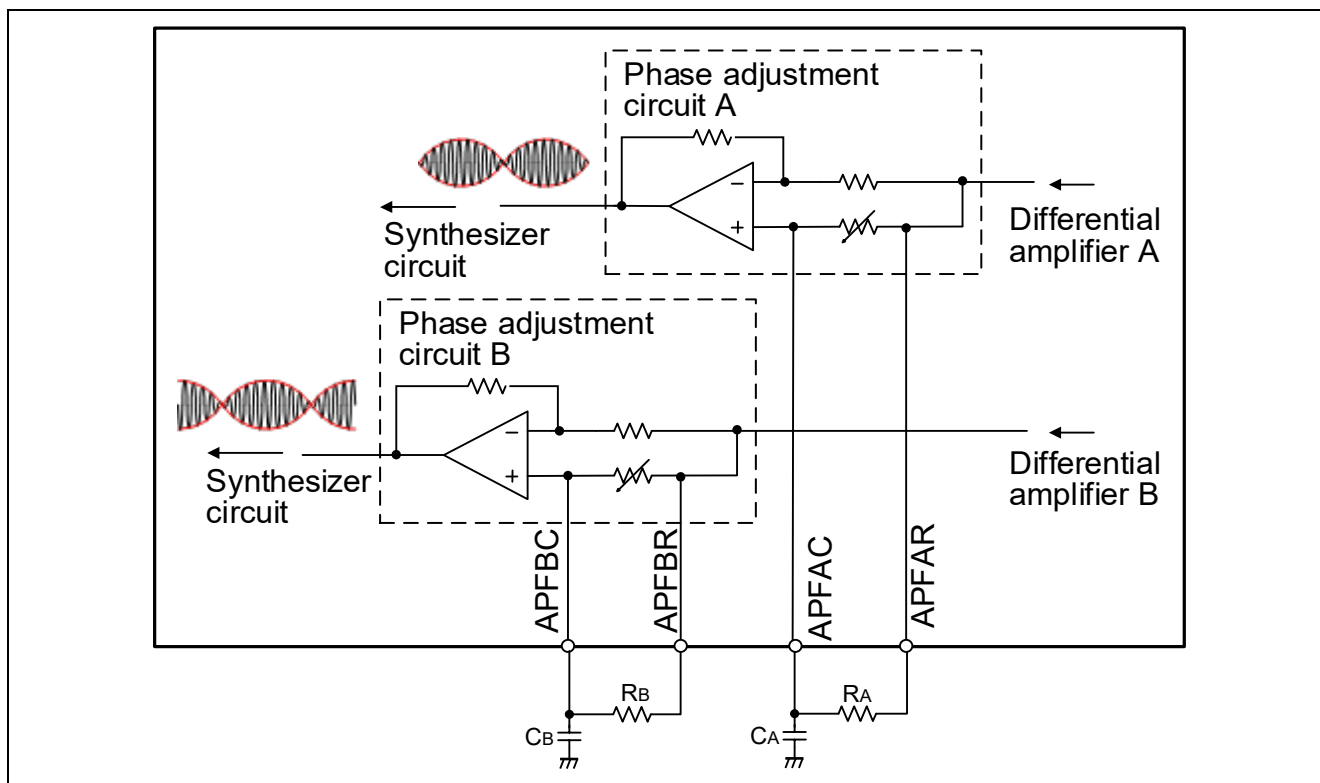


Figure 2.4 Phase Adjustment Circuits

Table 2.3 Example of Constants of Phase Adjustment Circuits

Excitation Frequency	Component	Number	Value	Tolerance	Temperature Characteristics
5 kHz	Resistor	R_A	56 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Resistor	R_B	51 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	1.5 nF	$\pm 1\%$	± 30 ppm/ $^{\circ}\text{C}$
	Capacitor	C_B	270 pF	$\pm 1\%$	± 30 ppm/ $^{\circ}\text{C}$
10 kHz	Resistor	R_A	56 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Resistor	R_B	43 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	750 pF	$\pm 1\%$	± 30 ppm/ $^{\circ}\text{C}$
	Capacitor	C_B	160 pF	$\pm 1\%$	± 30 ppm/ $^{\circ}\text{C}$
20 kHz	Resistor	R_A	62 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Resistor	R_B	43 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	330 pF	$\pm 1\%$	± 30 ppm/ $^{\circ}\text{C}$
	Capacitor	C_B	82 pF	$\pm 1\%$	± 30 ppm/ $^{\circ}\text{C}$

2.4 Filter Circuits

The filter circuits are intended to remove the signal components described in sections 2.4.1 and 2.4.2 below.

2.4.1 Magnetic Noise

When a motor is made to rotate by applying current, magnetic noise is generated when stray capacitance causes current flowing in the motor coils to be applied to the resolver coils. The level of generated noise varies with the motor and resolver to be used. The user needs to determine the frequencies that require removal and the attenuation rate according to the usage environment and the target accuracy.

2.4.2 Harmonics of the Excitation Control Signal

The harmonics the excitation control signal includes are removed in the input circuit for the resolver actuating signal. If filtering of the harmonics by the given circuit is not sufficient, they must be removed by a further filter circuit. Configure a circuit that includes at least a first-order low-pass filter unless otherwise specified.

The RAA3064002GFP and RAA3064003GFP each incorporate two operational amplifiers to configure the filter circuits. One operational amplifier can be configured as a multiple-feedback type filter by using the FAMPIN and FAMPOUT pins. The other operational amplifier can have various configurations because all input and output pins (BPFINP, BPFINN, and BPFOUT) of this operational amplifier are externally connectable.

When a resolver is attached to a brushless DC motor, the level of magnetic noise is generally low. However, when a resolver is attached to a stepping motor, the level of magnetic noise is higher. Accordingly, this application note provides two examples of filter configuration. Figure 2.5 shows an example of a configuration for a resolver in use with a brushless DC motor. Figure 2.6 shows an example of a configuration for a resolver in use with a stepping motor.

Table 2.4 and Table 2.5 list the constants in each case.

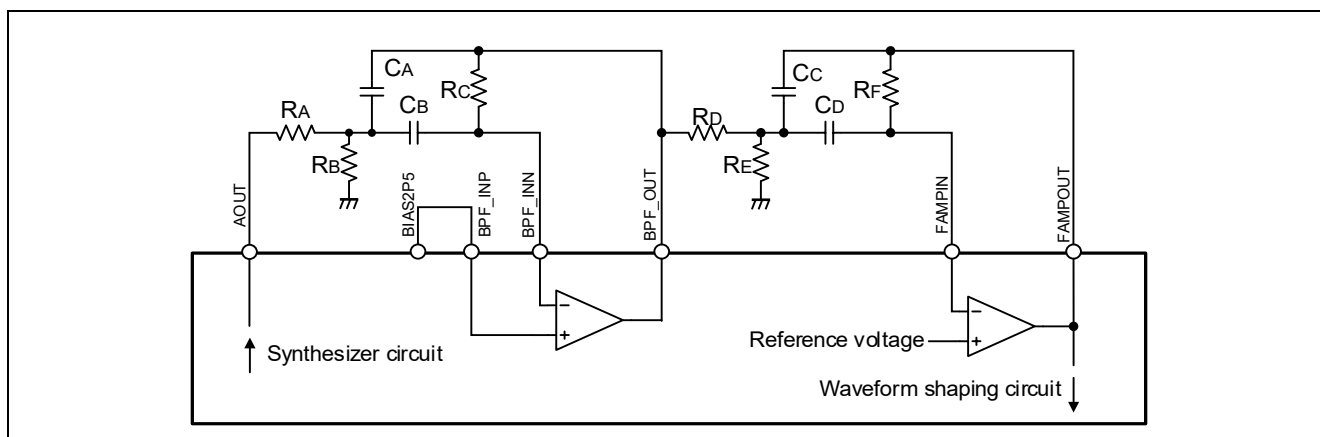


Figure 2.5 Configuration when a Resolver is in Use with a Brushless DC Motor

Table 2.4 Constants when a Resolver is in Use with a Brushless DC Motor

Excitation Frequency	Component	Number	Value	Tolerance	Temperature Characteristics
5 kHz	Resistor	RA	33 kΩ	±1%	±100 ppm/°C
	Resistor	RB	33 kΩ	±1%	±100 ppm/°C
	Resistor	RC	68 kΩ	±1%	±100 ppm/°C
	Resistor	RD	33 kΩ	±1%	±100 ppm/°C
	Resistor	RE	33 kΩ	±1%	±100 ppm/°C
	Resistor	RF	68 kΩ	±1%	±100 ppm/°C
	Capacitor	CA	1.0 nF	±1%	±30 ppm/°C
	Capacitor	CB	1.0 nF	±1%	±30 ppm/°C
	Capacitor	CC	1.0 nF	±1%	±30 ppm/°C
	Capacitor	CD	1.0 nF	±1%	±30 ppm/°C
10 kHz	Resistor	RA	33 kΩ	±1%	±100 ppm/°C
	Resistor	RB	33 kΩ	±1%	±100 ppm/°C
	Resistor	RC	68 kΩ	±1%	±100 ppm/°C
	Resistor	RD	33 kΩ	±1%	±100 ppm/°C
	Resistor	RE	33 kΩ	±1%	±100 ppm/°C
	Resistor	RF	68 kΩ	±1%	±100 ppm/°C
	Capacitor	CA	470 pF	±1%	±30 ppm/°C
	Capacitor	CB	470 pF	±1%	±30 ppm/°C
	Capacitor	CC	470 pF	±1%	±30 ppm/°C
	Capacitor	CD	470 pF	±1%	±30 ppm/°C

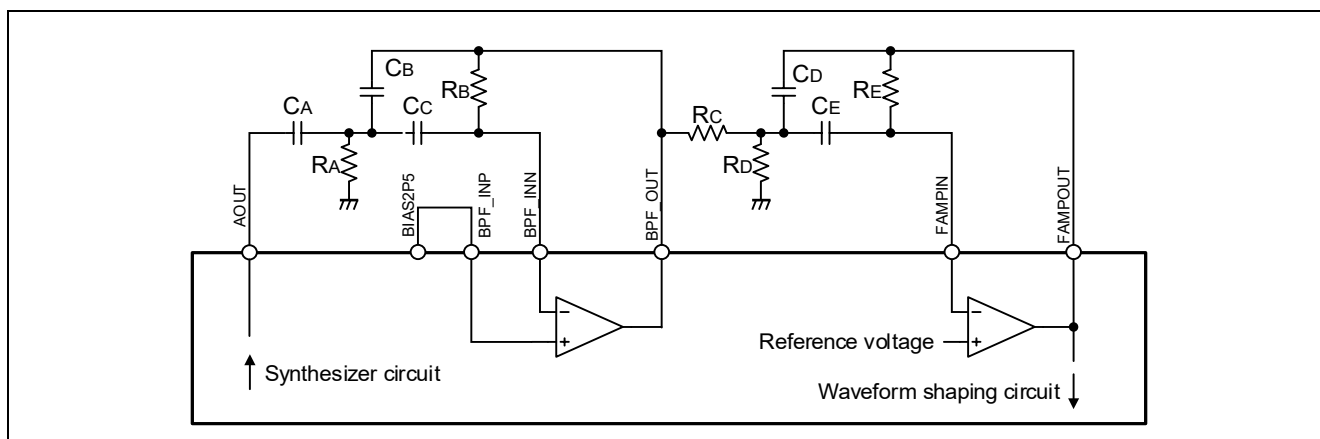


Figure 2.6 Configuration when a Resolver is in Use with a Stepping Motor

Table 2.5 Constants when a Resolver is in Use with a Stepping Motor

Excitation Frequency	Component	Number	Value	Tolerance	Temperature Characteristics
20 kHz	Resistor	RA	15 kΩ	±1%	±100 ppm/°C
	Resistor	RB	100 kΩ	±1%	±100 ppm/°C
	Resistor	RC	4.7 kΩ	±1%	±100 ppm/°C
	Resistor	RD	6.8 kΩ	±1%	±100 ppm/°C
	Resistor	RE	47 kΩ	±1%	±100 ppm/°C
	Capacitor	CA	220 pF	±1%	±30 ppm/°C
	Capacitor	CB	220 pF	±1%	±30 ppm/°C
	Capacitor	CC	220 pF	±1%	±30 ppm/°C
	Capacitor	CD	220 pF	±1%	±30 ppm/°C
	Capacitor	CE	3.3 nF	±1%	±30 ppm/°C

2.5 Low-Pass Filter Circuit for the Correction Signal

The RAA3064002GFP and RAA3064003GFP each require a low-pass filter circuit for the correction signal for the correction of errors due to errors in the resolver coils. A PWM signal is output by the MCU as the correction signal for this circuit.

The input circuit for the correction circuit converts the signal from the MCU to a pseudo-sine-wave signal. The converted signal is then input to the CC pin of the given IC. Figure 2.7 shows the low-pass filter circuit. Table 2.6 lists typical constants.

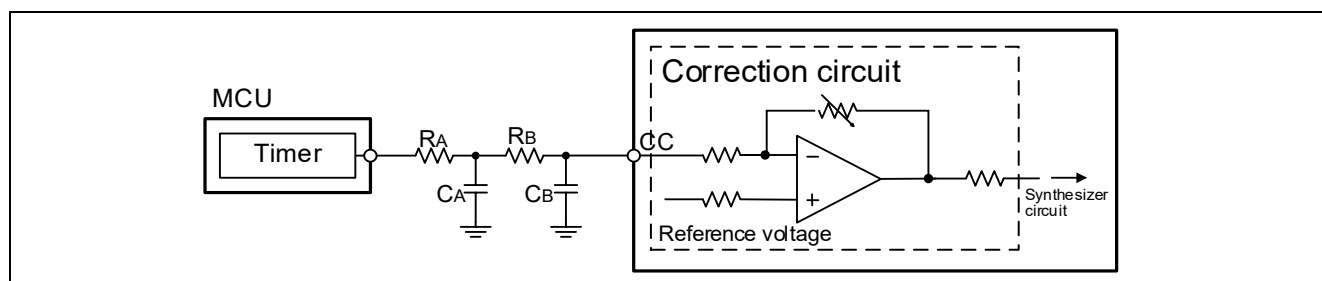


Figure 2.7 Low-Pass Filter Circuit for the Correction Signal

Table 2.6 Example of Constants of Low-Pass Filter Circuit for the Correction Signal

Excitation Frequency	Component	Number	Value	Tolerance	Temperature Characteristics
5 kHz	Resistor	R_A	2 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Resistor	R_B	20 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	15 nF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$
	Capacitor	C_B	1.5 nF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$
10 kHz	Resistor	R_A	1.5 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Resistor	R_B	15 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	10 nF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$
	Capacitor	C_B	1 nF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$
20 kHz	Resistor	R_A	2 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Resistor	R_B	20 k Ω	$\pm 1\%$	± 100 ppm/ $^{\circ}\text{C}$
	Capacitor	C_A	3.3 nF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$
	Capacitor	C_B	330 pF	$\pm 5\%$	± 30 ppm/ $^{\circ}\text{C}$

2.6 Resolver Signal Input Circuit

2.6.1 Using a Current-Detection Type Resolver

2.6.1.1 Overview

When using a current-detection type resolver, detection resistors must be connected to the outputs of the resolver (Figure 2.8). Select the values of the detection resistors and the gain of the differential amplifiers to suit the characteristics of the resolver to be used. See section 2.6.1.2 below to select the values and gain.

SPI communications are used to set the gain of the differential amplifiers. For details of SPI communications and gain settings, see *RAA3064002GFP/RAA3064003GFP Resolver-to-Digital Converters User's Manual: Hardware (R03UZ0002EJ0100)*.

2.6.1.2 Selecting the Value R_s of the Detection Resistors and Gain G_d of the Differential Amplifiers

Use the following expressions to calculate index A and index B from the resolver impedance Z (Ω) and depth of modulation m .

$$\text{Index } A = 0.67Z$$

$$\text{Index } B = \frac{37.3}{m \cdot G_d}$$

G_d in the expression for index B is the gain of the differential amplifiers. Select a gain value from among the four values in table 2.7 such that the absolute value of the difference between index A and index B is minimized.

Select the value R_s of the detection resistors as desired from the following range based on the value of index B. That is, select R_s to be nearly equal to B unless otherwise specified.

$$0.9B \leq R_s \leq 1.1B$$

Table 2.7 Selectable Gain Values of the Differential Amplifiers

Name	Selectable Value			
Gain G_d (times) of the differential amplifiers	2	4	8	16.5

Example of calculation: When resolver inductance $L = 3$ mH, modulation depth $m = 0.1$ (10%), and excitation frequency $f = 5$ kHz,

$$\text{Resolver impedance } Z = 2\pi fL = 2\pi \times 5000 \times 0.003 = 94.2 \Omega$$

$$\text{Index } A = 0.67Z = 0.67 \times 94.2 = 63.1$$

$$\text{Index } B = \frac{37.3}{m \cdot G_d} = \frac{37.3}{0.1 \times 8} = 46.6$$

If $G_d = 8$ in Table 2.7 is selected, $|A - B|$ equals 15, which is a minimal difference between the absolute values of index A and index B.

Accordingly, the value R_s of the detection resistors is obtained as follows:

$$0.9B \leq R_s \leq 1.1B.$$

$$0.9B \times 46.6 \leq R_s \leq 1.1 \times 46.6$$

$$41.9 \leq R_s \leq 51.2$$

$B \approx R_s = 51 \Omega$ is selected from the E24 series. We recommend using a resolver with a resistor accuracy of $\pm 0.1\%$ as much as possible to avoid angle errors.

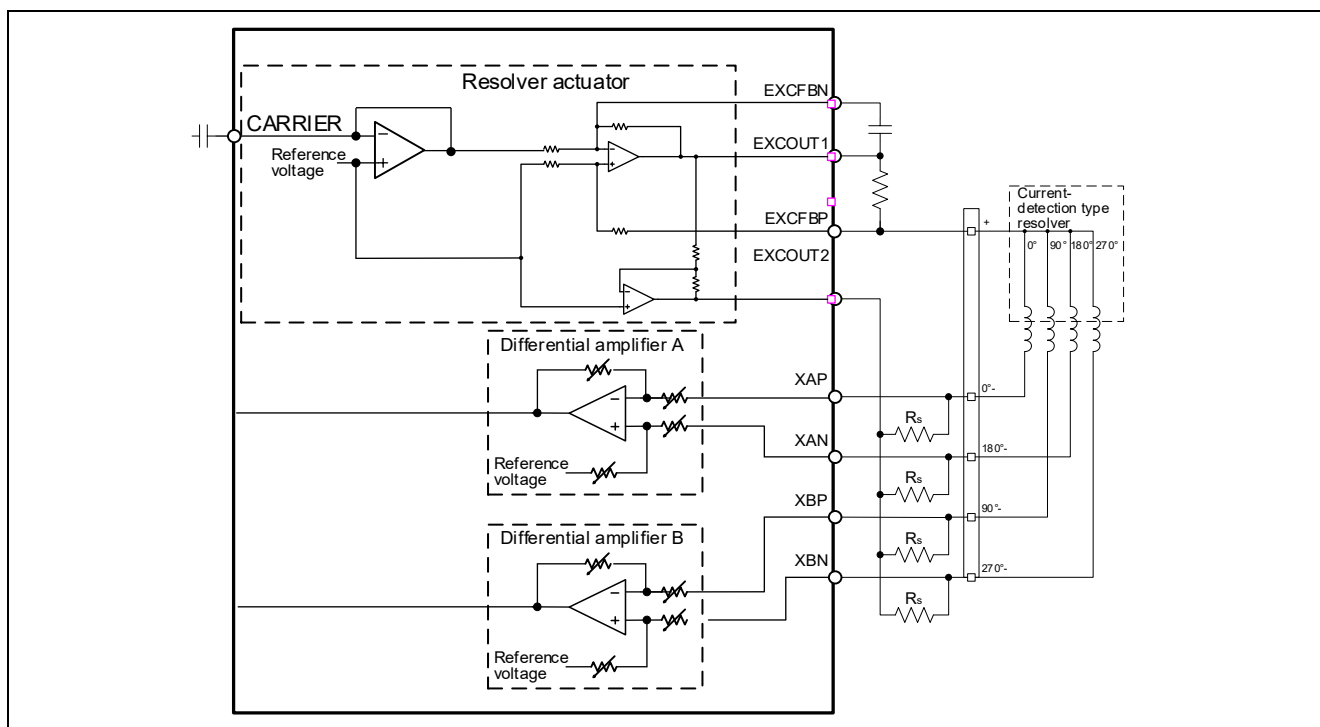


Figure 2.8 Detection Resistors Connected to the Outputs of the Resolver

2.6.2 Using a Transformer-Type Resolver

2.6.2.1 Gain of Differential Amplifiers

Set the gain of differential amplifiers that suits the characteristics of the resolver to be used. If a transformer-type resolver is to be used, see the voltage ratio in the resolver data sheet.

Table 2.8 Gain Setting for Differential Amplifiers

Voltage Ratio	Gain Setting
At least 0.2	8 times
Less than 0.2	16.5 times

Note that setting of the registers is handled through SPI communications. For details of SPI communications and registers, see *RAA3064002GFP/RAA3064003GFP Resolver-to-Digital Converters User's Manual: Hardware (R03UZ0002EJ0100)*.

2.6.2.2 Resistors to Detect Disconnection from the Resolver Sensor

The RAA3064002GFP and RAA3064003GFP each are capable of detecting disconnection from the resolver sensor. Only connect the resistors to detect disconnection as shown in Figure 2.9 when using a transformer-type resolver. Set the values of the resistors R_A , R_B , R_C , R_C , and R_D to at least 100 k Ω such that detection of resolver signals is not affected. For details on detection of disconnection, see section 4.4, Detection of Disconnection.

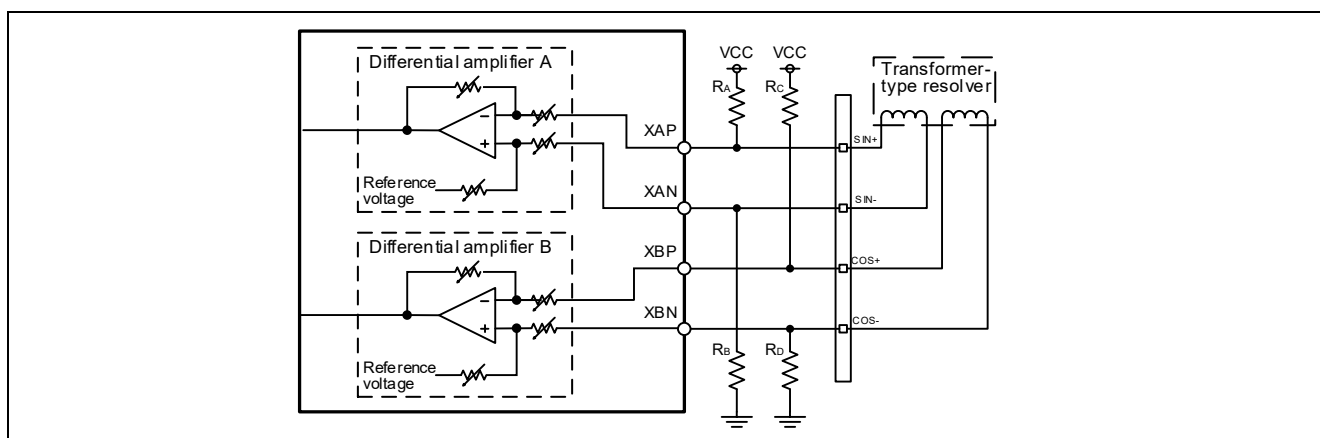


Figure 2.9 Resistors to Detect Disconnection from the Resolver Sensor

2.7 Filter Circuits for the Current Detection Circuit

The current detection circuit converts the current flowing in the shunt resistors of the motor to the voltage. Connecting the shunt resistors for use in current detection may lead to the generation of noise by the surge voltage of the MOSFET motor driver. The external components that configure low-pass filters are required to eliminate this noise. Note that, when resistors for the filter circuits are connected in series to the I1INN and I2INN pins ($n = 1$ or 2), the value should be no greater than $100\ \Omega$. Relatively larger resistances may increase input impedance, resulting in the gain value for the current detection circuit being out of the specified range.

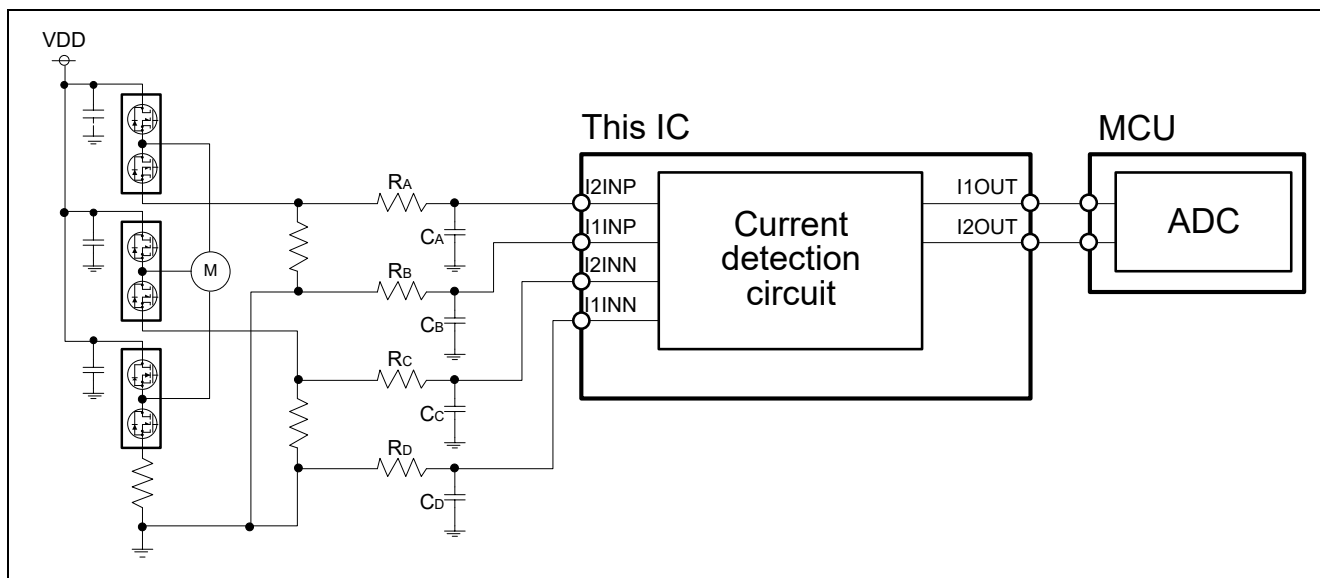


Figure 2.10 Filter Circuits for the Current Detection Circuit

2.8 Power-Supply Circuit

The RAA3064002GFP and RAA3064003GFP each have three pairs of power supply pins.

- AV_{DD} and AV_{SS}
Power supply pins for the analog circuits in the RAA3064002GFP and RAA3064003GFP
- IOV_{DD} and IOV_{SS}
Power supply pin for digital circuits in the RAA3064002GFP and RAA3064003GFP
- EV_{DD} and EV_{SS}
Power supply pins for the constant-current excitation circuit in the RAA3064002GFP and RAA3064003GFP

Website and Support

Renesas Electronics website

<http://www.renesas.com/>

Inquiries

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Dec.26.19	—	First edition issued
1.10	Mar.16.20	5	Table 2.1 Example of the Constants of the Circuit for the Input of the Resolver Actuating Signal: Tolerance values corrected
		6	Table 2.2 Example of Constants of the Constant-Current Excitation Circuit: Values corrected
		7	Table 2.3 Example of Constants of Phase Adjustment Circuits: Values corrected
		11	Table 2.6 Example of Constants of Low-Pass Filter Circuit for the Correction Signal: Values corrected
		—	Section 3 Required MCU Resources: Deleted
		—	Section 4 Troubleshooting: Deleted

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity.

Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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