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Brushless motor driving device, driving method for a brushless motor, and brushless motor

Abstract

According to one embodiment, a motor driving device includes an output part that supplies an exciting current to an exciting coil, a position detection part that detects a rotational position of a rotor, and a driving control part that produces a driving signal that is based on a detection signal from the position detection part and supplies it to the output part. The position detection part has first, second, and third detection elements that are integrally integrated together with the driving control part and detect rotational positions of the rotor.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) The present application is a continuation of U.S. patent application Ser. No. 17/381,159, filed on Jul. 20, 2021, which application is based upon and claims the benefit of priority to Japanese Patent Application No. 2021-038557 filed on Mar. 10, 2021, the entire contents of which are incorporated by reference in the present application.

FIELD
(1) Embodiments described herein generally relate to a brushless motor driving device, a driving method for a brushless motor, and a brushless motor.
BACKGROUND
(2) A technique of a three-phase brushless motor has conventionally been disclosed where three sensors that detect a rotational position of a rotor are arranged at positions with mutual phase differences of 120 degrees as an electrical angle. Three sensors are provided separately, so that the number of components is increased. Furthermore, three sensors are mounted at positions with mutual phase differences of 120 degrees, so that a support base with large surface area for mounting the sensors thereon is needed and a cost of a motor is increased. Furthermore, adjustment of arrangement positions of sensors is needed for each motor and is complicated. On the other hand, in a case where one sensor is provided, there is a risk of defective activation of a motor. A brushless motor driving device, a driving method for a brushless motor, and a brushless motor are desired that are of high versatility and are also capable of reducing a cost of a motor.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a diagram that generally illustrates a circuit configuration of a brushless motor driving device according to a first embodiment.
(2) FIG. **2** is a diagram that schematically illustrates an arrangement relationship between a brushless motor driving device and a rotor.
(3) FIG. **3** is a diagram for explaining a driving method for a brushless motor driving device.
(4) FIG. **4** is a diagram for explaining a production method for a driving signal of a brushless motor driving device at a time of normal rotation of a rotor.
(5) FIG. **5** is a diagram for explaining a production method for a driving signal of a brushless motor driving device at a time of reverse rotation of a rotor.
(6) FIG. **6** is a diagram for explaining a signal production method in a case where a phase difference is a threshold or less.
(7) FIG. **7** is a diagram for explaining, in detail, a signal production method in a case where a phase difference is a threshold or less.
(8) FIG. **8** is a diagram for explaining a signal production method in a case where a phase

difference is greater than a threshold.
(9) FIG. **9** is a diagram for explaining, in detail, a signal production method in a case where a phase difference is greater than a threshold.
(10) FIG. **10** is a diagram for explaining an offset of an output signal of an auxiliary sensor and a signal production method thereof.
(11) FIG. **11** is a diagram that illustrates a flow of one embodiment of calibration.
(12) FIG. **12** is a diagram that illustrates an example of a plane pattern where a brushless motor driving device is integrated therein.
(13) FIG. **13** is an exploded perspective view of one embodiment of a motor that incorporates a brushless motor driving device therein.
DETAILED DESCRIPTION
(14) According to one embodiment, a motor driving device includes an output part that supplies an exciting current to an exciting coil that generates a magnetic field that rotates a rotor, a position detection part that detects a rotational position of the rotor, and a driving control part that produces a driving signal that is based on a detection signal from the position detection part and supplies it to the output part, wherein the position detection part has a first detection element that detects a rotational position of the rotor, a second detection element that detects a rotational position of the rotor prior to the first detection element, and a third detection element that detects a rotational position of the rotor subsequent to the first detection element, and the first to third detection elements are integrally integrated.
(15) Hereinafter, a brushless motor driving device, a driving method for a brushless motor, and a brushless motor according to an embodiment will be explained in detail with reference to the accompanying drawings. Additionally, the present invention is not limited by these embodiments.
First Embodiment
(16) FIG. **1** is a diagram that generally illustrates a circuit configuration of a brushless motor driving device **100** according to a first embodiment. The brushless motor driving device **100** according to the present embodiment (that will be called a driving device **100** below) has a sensor part **10**. The sensor part **10** has a main sensor **11**, an auxiliary sensor **12**, and an auxiliary sensor **13**. For example, each of the sensors **11**, **12**, and **13** is composed of a Hall element or is configured as an integrated circuit that includes an amplifier circuit (non-illustrated) that amplifies an output signal of a Hall element.
(17) It is possible to provide a Hall element of each of the sensors **11**, **12**, **13** that is composed of silicon or a compound semiconductor such as GaAs or InAs. In a case where a Hall element is composed of silicon, it is possible to integrate it on a single silicon substrate (non-illustrated) together with other circuit parts that compose the driving device **100**. In a case where a Hall element is composed of a compound semiconductor, it is possible to integrate a separate chip (non-illustrated) where a Hall element that is composed of a compound semiconductor is formed with a silicon substrate where other circuit parts are formed, by a multichip configuration, and integrally integrate them by, for example, a mold resin.
(18) The driving device **100** according to the present embodiment has a detection part **20**. The detection part **20** has an offset cancel part **21** where an output signal of the main sensor **11** is supplied. It is possible to provide, for example, the offset cancel part **21** that is configured to subtract an output signal that is obtained by changing a direction of a current that is supplied to a Hall element (non-illustrated) of the main sensor **11**. An output signal of the offset cancel part **21** is supplied to a comparator **22**. For example, the comparator **22** has a hysteresis characteristic and outputs a digital signal where an H level and an L level are changed at a zero cross point. The comparator **22** has a hysteresis characteristic, so that it is possible to provide a configuration to prevent chattering.
(19) Output signals of the auxiliary sensors **12**, **13** are supplied to comparators **23**, **24**, respectively. The comparators **23**, **24** compare output signals of the auxiliary sensors **12**, **13** with predetermined

thresholds and output digital signals that are changed to an H level or an L level depending on results of comparison thereof. The comparators **23**, **24** are composed of, for example, window comparators that compare input signals with two threshold voltages and output digital signals at an H level or an L level depending on results of comparison thereof. A relationship between setting of threshold voltages that are supplied to the comparators **23**, **24** and output signals of the comparators **23**, **24** will be described later.

(20) The detection part **20** has an AD converter **25** where an output of the offset cancel part **21** is supplied, and AD converters **26**, **27** where output signals of the auxiliary sensors **12**, **13** are supplied. The respective AD converters **25** to **27** convert output signals of the respective sensors **11**, **12**, and **13** into digital signals and output them.

(21) The driving device **100** according to the present embodiment has a control part **30**. The control part **30** has a signal processing part **31**, a threshold voltage production part **32**, a phase difference detection part **33**, a sensor output selection part **34**, and a driving signal production part **35**.

(22) The signal processing part **31** executes a predetermined arithmetic process by using an output signal of the respective AD converters **25** to **27**. For example, the signal processing part **31** executes an arithmetic process by using digital signals that are acquired from the respective AD converters **25** to **27** and supplies a result of processing thereof to the threshold voltage production part **32**, the phase difference detection part **33**, and the driving signal production part **35**.

(23) The driving device **100** according to the present embodiment has a memory part **50**. The memory part **50** holds results of selection of the auxiliary sensors that are acquired in calibration that is executed at a time of motor activation and values of output signals of the auxiliary sensors **12**, **13**. Furthermore, the memory part **50** holds data of a driving condition in calibration at a time of activation thereof. The driving signal production part **35** produces a driving signal that rotates a rotor **62** at a constant frequency (rotational frequency), for example, in response to a signal that is supplied at a predetermined timing from the memory part **50** through the signal processing part **31** in calibration thereof.

(24) The threshold voltage production part **32** analog-converts a digital signal that is supplied from the signal processing part **31**, produces threshold voltages of the comparators **23**, **24** from output signals of the AD converters **26**, **27** that are acquired in calibration that is executed at a time of motor activation, and supplies them to the comparators **23**, **24**. Calibration will be described later.

(25) The phase difference detection part **33** detects phase differences among output signals of the respective sensors **11**, **12**, **13** that are supplied from the signal processing part **31**. An output signal of the phase difference detection part **33** is supplied to the sensor output selection part **34** through the signal processing part **31**.

(26) The sensor output selection part **34** selects a signal that is supplied to the driving signal production part **35**, in response to an output signal of the phase difference detection part **33** that is supplied through the signal processing part **31**. In a case where a phase difference between an output signal of the main sensor **11** and an output signal of the auxiliary sensor **12** at a time of normal rotation of the rotor **62** is a predetermined threshold or less, the sensor output selection part **34** selects output signals from the main sensor **11** and the auxiliary sensor **12** and supplies them to the driving signal production part **35**. A threshold is, for example, 30 degrees as an electrical angle. A threshold and a selection method for an output signal will be described later.

(27) The driving signal production part **35** produces a driving signal by using a signal that is supplied from the sensor output selection part **34** and supplies it to an output circuit part **40**.

(28) The output circuit part **40** has output transistors **41** to **46**. The respective output transistors **41** to **46** have free wheel diodes **411** to **416** between sources-drains thereof. The respective output transistors **41** to **46** of the output circuit part **40** compose a bridge circuit and execute, for example, 120-degree conduction in response to a driving signal from the driving signal production part **35**. The respective output transistors **41** to **46** supply exciting currents to exciting coils LU, LV, LW of a coil part **61** of a motor **60** through output lines **301** to **303**. The exciting coils LU, LV, LW are

excited by exciting currents so as to generate magnetic fields. The rotor **62** that is composed of a permanent magnet is rotated depending on magnetic fields that are generated by the exciting coils LU, LV, LW. Additionally, the exciting coils LU, LV, LW may be composed of delta connection. The driving device **100** that includes the sensor part **10** is arranged at a position that is close to the rotor **62** of the motor **60**.

(29) In the driving device **100** according to a first embodiment, the main sensor **11**, the auxiliary sensor **12**, and the auxiliary sensor **13** are integrally integrated. Furthermore, in the driving device **100**, results of selection of the auxiliary sensors **12**, **13** that are acquired at a time of calibration and values of output signals of the respective auxiliary sensors **12**, **13** are held in the memory part **50** and the threshold voltage production part **32** sets threshold voltages of the respective comparators **23**, **24**. Therefore, it is possible to change setting values of threshold voltages for each motor where the driving device **100** is mounted, so that a configuration with high versatility is provided.

(30) FIG. **2** is a diagram that schematically illustrates an arrangement relationship between the driving device **100** and the rotor **62**. A component that corresponds to that of an embodiment as already described will be provided with an identical sign so as to provide a redundant description only in a case of need. Hereinafter, the same applies. FIG. **2** illustrates an example of a case of an inner rotor. For example, the rotor **62** is composed of two poles such as an N pole and an S pole as illustrated in the figure. The driving device **100** where the respective sensors **11**, **12**, **13** of the sensor part **10** are integrally integrated is provided so as to be close to the rotor **62**. A center line **600** passes through a center of the main sensor **11**. A broken line **603** indicates a line that passes through a center of the auxiliary sensor **12** from a center O of the rotor **62** and a broken line **604** indicates a line that passes through a center of the auxiliary sensor **13** from the center O.

(31) Phase differences between an output signal of the main sensor **11** and output signals of the respective auxiliary sensors **12**, **13** are produced by angles $\alpha 1$, $\alpha 2$ that are produced between the center line **600** and the respective broken lines **603**, **604**. Preferably, the auxiliary sensors **12**, **13** are provided at line-symmetric positions relative to the main sensor **11**, that is, the center line **600** as a center. That is, arrangement is provided in such a manner that $\alpha 1$ and $\alpha 2$ are equal. The auxiliary sensors **12**, **13** are arranged at line-symmetric positions relative to the center line **600** as a center, so that it is possible to provide a configuration that has a relationship where a phase of an output signal of one of the auxiliary sensors **12**, **13** is advanced relative to that of an output signal of the main sensor **11** and an output signal of the other is delayed by an identical phase difference.

(32) At a time of normal rotation of the rotor **62** as indicated by an arrow **601**, the auxiliary sensor **12** outputs an output signal that precedes the main sensor **11** and the auxiliary sensor **13** outputs an output signal that follows it. At a time of reverse rotation as indicated by an arrow **602**, the auxiliary sensor **13** outputs an output signal that precedes the main sensor **11** and the auxiliary sensor **12** outputs an output signal that follows the main sensor **11**. The driving device **100** according to the present embodiment detects a rotational position of the rotor **62** by utilizing phase differences between output signals of the main sensor **11** and the auxiliary sensors **12**, **13**. Furthermore, an anteroposterior relation between output signals of the main sensor **11** and the auxiliary sensors **12**, **13** differs depending on a direction of rotation of the rotor **62**, so that it is possible to detect a direction of rotation of the rotor **62** and it is possible to avoid a risk of defective activation of the motor **60**. Additionally, rotation of the rotor **62** may be represented as rotation of the motor **60**.

(33) Output signals of the respective sensors **11**, **12**, and **13** are generated in response to approaching of an N pole and an S pole of a permanent magnet of the rotor **62** to the respective sensors **11**, **12**, and **13**. That is, a magnitude of an output signal of each of the sensors **11**, **12**, and **13** does not depend on a rotational speed of the rotor **62**. Therefore, levels of output signals of the respective auxiliary sensors **12**, **13** that are acquired by calibration that is executed at a time of activation thereof are set as threshold voltages of the comparators **23**, **24** and output signals from the respective auxiliary sensors **12**, **13** are compared with these threshold voltages in the respective

comparators **23**, **24**, so that it is possible to detect a rotational positon of the rotor **62**.

(34) Additionally, in a case of a configuration of an outer rotor, the driving device **100** is arranged on an inner side of the rotor **62**, that is, on a side of the center O. Similarly to a configuration of an inner rotor, it is possible to provide a configuration that causes the respective sensors **11**, **12**, **13** to respond to rotation of the rotor **62**.

(35) Next, a driving method for the driving device **100** will be explained by using FIG. **3**. FIG. **3** is a diagram for explaining a driving method for a brushless motor driving device, and a diagram for explaining a relationship among output signals of the respective sensors **11**, **12**, and **13** at a time of normal rotation of the rotor **62**. A solid line **501** in a top section indicates an angle of rotation of the rotor **62**. In a case where the rotor **62** is composed of a permanent magnet with two poles, an angle of rotation of the rotor **62** corresponds to an electrical angle. P**18** indicates a timing of an angle of rotation of 180 degrees and P**00** indicates a timing of an angle of rotation of 360 degrees, therefore, an angle of rotation of 0 degrees.

(36) A subsequent section indicates an output signal **502** of the main sensor **11** that is supplied through the offset cancel part **21**, as a pseudo-sine wave. For example, the main sensor **11** generates a negative voltage as an N pole of the rotor **62** approaches, or generates a positive voltage as an S pole thereof approaches. The output signal **502** of the main sensor **11** is zero at timings of connection of an S pole and an N pole of the rotor **62**. That is, the output signal **502** of the main sensor **11** is zero at timings P**0**, P**10** that correspond to timings of connection of an S pole and an N pole of the rotor **62**. The timings P**0**, P**10** are zero cross points.

(37) A subsequent section indicates output signals **503**, **504** of the auxiliary sensors **12** and **13**, as pseudo-sine waves. Conveniently, indices (**12**), (**13**) that indicate the auxiliary sensors **12**, **13** that correspond to the output signals **503**, **504** are additionally provided. For example, the auxiliary sensors **12**, **13** generate negative voltages as an N pole of the rotor **62** approaches, or generate positive voltages as an S pole thereof approaches, similarly to the main sensor **11**. The output signal **503** of the auxiliary sensor **12** is compared with a threshold voltage thA**1** and a threshold voltage thA**2** in the comparator **23**. Depending on results of comparison with the threshold voltages thA**1**, thA**2**, a timing P**1** when a phase is advanced by 120 degrees relative to a timing P**18** when the output signal **502** of the main sensor **11** is zero, and a timing P**2** when a phase is delayed by 60 degrees relative thereto are detected.

(38) Similarly, the output signal **504** of the auxiliary sensor **13** is compared with a threshold voltage thB**1** and a threshold voltage thB**2** in the comparator **24**, and a timing P**3** when a phase is advanced by 60 degrees relative to the timing P**18** when the output signal **502** of the main sensor **11** is zero and a timing P**4** when a phase is delayed by 120 degrees are detected. For example, the respective threshold voltages thA**1**, thA**2**, thB**1**, thB**2** are set based on output levels of output signals of the respective auxiliary sensors **12**, **13** at a time of calibration that is executed at a time of activation of the motor **60**. Calibration will be described later.

(39) A subsequent section indicates a digital signal **505** that is produced from the output signal **502** of the main sensor **11**. A waveform of the output signal **502** of the main sensor **11** that is supplied through the offset cancel part **21** is shaped by the comparator **22** so as to obtain the digital signal **505**. The digital signal **505** is changed from an L level to an H level at the timing P**0** when the output signal **502** is changed from a negative voltage to a positive voltage, that is, a zero cross point. For example, the comparator **22** has a hysteresis characteristic where switching between an H level and an L level is caused at a zero cross point of the output signal **502**.

(40) A subsequent section indicates a digital signal **506** of the auxiliary sensor **12** that is output by the comparator **23**. For example, the comparator **23** outputs the digital signal **505** at an H level and an L level in response to the threshold voltage thA**1** on a low side and the threshold voltage thA**2** on a high side.

(41) A subsequent section indicates a digital signal **507** of the auxiliary sensor **13** that is output by the comparator **24**. For example, the comparator **24** outputs a digital signal at an H level and an L

level in response to the threshold voltage thB**1** on a low side and the threshold voltage thB**2** on a high side.

(42) The threshold voltages thA**1**, thA**2**, thB**1**, thB**2** of the respective sensors **12**, **13** are set in calibration at a time of motor activation. The threshold voltages thA**1**, thA**2**, thB**1**, thB**2** are set based on output levels of output signals of the auxiliary sensors **12**, **13** at a timing when a relationship is provided in such a manner that respective phase differences of electrical angles are 120 degrees, in the output signal **502** of the main sensor **11**.

(43) The driving signal production part **35** produces driving signals HU, LU, HV, LV, HW, LW that are supplied to the respective output transistors **41** to **46**, by using the three digital signals **505** to **507**. The driving signal HU as indicated by a solid line **610** in a subsequent section is supplied to the output transistor **41** in an upper section for a U phase and the driving signal LU as indicated by a solid line **611** in a subsequent section is supplied to the output transistor **44** in a lower section for the U phase.

(44) Similarly, the driving signal HV as indicated by a solid line **612** in a subsequent section is supplied to the output transistor **42** on an upper section for a V phase and the driving signal LV as indicated by a solid line **613** in a subsequent section is supplied to the output transistor **45** on a lower section for the V phase. Similarly, the driving signal HW as indicated by a solid line **614** in a subsequent section is supplied to the output transistor **43** on an upper section for a W phase and the driving signal LW as indicated by a solid line **615** in a subsequent section is supplied to the output transistor **46** on a lower section for the W phase.

(45) The respective output transistors **41** to **46** are driven by the driving signals HU, LU, HV, LV, HW, LW, for example, in 120-degree conduction. Additionally, for explanatory convenience, the driving signals HU, HV, HW indicate signals for turning on P-type output transistors **41** to **43**, so that indication is provided in such a manner that a logic level of H/L is inverted.

(46) In the driving device **100** according to the present embodiment, the driving signals HU, LU, HV, LV, HW, LW are produced based on output levels of output signals of the main sensor **11** and the two auxiliary sensors **12**, **13** that are integrally integrated. The threshold voltages thA**1**, thA**2**, thB**1**, thB**2** of the comparators **23**, **24** are set by output levels of output signals of the auxiliary sensors **12**, **13** that are detected at a point of time for a predetermined phase difference relative to an output signal of the main sensor **11** at a time of calibration that is executed at a time of activation of the motor **60**. Output signals from the auxiliary sensors **12**, **13** are compared with threshold voltages, so that it is possible to detect a rotational position of the rotor **62**. Even though the main sensor **11** and the auxiliary sensors **12**, **13** are formed integrally, it is possible to detect a rotational position of the rotor **62** similarly to a conventional three-phase brushless motor. Furthermore, it is possible to set proper threshold voltages for each motor in calibration, so that it is possible to provide the driving device **100** with versatility.

(47) Next, one embodiment of a production method for a driving signal that is executed by the driving device **100** at a time of normal rotation of the rotor **62** will be explained by using FIG. **4**. FIG. **4** is a diagram for explaining output signals of the respective sensors **11**, **12**, **13** at a time of normal rotation of the rotor **62**. Production of signals in a top section to a fifth section is identical to that of FIG. **3** as already described. In the present embodiment, a digital signal **2** is produced by using the digital signal **505** of the main sensor **11** and a digital signal **1** of the auxiliary sensor **12**.

(48) For example, a period of time T**2** is measured that corresponds to a phase difference of 60 degrees between the timing P**18** of rising of the digital signal **505** of the main sensor **11** and the timing P**2** of falling of the digital signal **1** of the auxiliary sensor **12**. Measurement is executed by, for example, a counter (non-illustrated) that is provided in the signal processing part **31**. An arithmetic process is executed by using the measured period of time T**2** in the signal processing part **31** so as to calculate periods of time T**3**, T**1**, and T**4** to T**6** that correspond to phase differences of 60 degrees. The digital signal **2** with a phase where the phase is delayed by 120 degrees relative to the digital signal **505** that is produced depending on the output signal **502** of the main sensor **11**

is produced by using the measured period of time T**2** and the calculated periods of time T**1**, T**3** to T**6**. A total value of the periods of time T**1** to T**6** is one cycle of the digital signal **2**. The digital signal **2** is produced in the driving signal production part **35**.

(49) Additionally, although it is also possible to execute an arithmetic process by using only the digital signal **505** of the main sensor **11** so as to produce the digital signal **2** with a phase where the phase is delayed by 120 degrees, it is possible to produce the digital signal **2** that is more accurate, by also using information of the auxiliary sensor **12**. Furthermore, it is also possible to estimate the period of time T**3** by using information of a frequency variation in several cycles.

(50) In a signal production method according to the present embodiment, an arithmetic process is executed by using the digital signal **505** of the main sensor **11** and the digital signal **1** of the auxiliary sensor **12** so as to produce the digital signal **2** where an H level and an L level are changed at a timing of a predetermined phase difference. Specifically, the digital signal **2** as indicated by a solid line **508** is produced where a phase thereof is delayed by 120 degrees relative to the output signal **502** of the main sensor **11**. A method that produces a driving signal by using the main sensor **11**, the digital signal **1** of the auxiliary sensor **12**, and the digital signal **2** is similar to that of an example of FIG. **3** and hence is omitted. The driving signals HU, LU, HV, LV, HW, LW are produced by the driving signal production part **35**.

(51) A signal production method where a production method for the digital signal **1** and the digital signal **2** differs depending on a phase difference between the output signal **502** of the main sensor **11** and the output signal **503** of the auxiliary sensor **12** will be described later.

(52) FIG. **5** is a diagram for explaining a production method for output signals of the respective sensors **11**, **12**, **13** and a driving signal at a time of reverse rotation of the rotor **62**. A top section indicates an angle of rotation of the rotor **62** by a solid line **511**. A subsequent section indicates an output signal **512** of the main sensor **11**.

(53) A subsequent section indicates output signals of the auxiliary sensors **12**, **13** by solid lines **513**, **514**, respectively. A relationship between magnetic poles of a permanent magnet of the rotor **62** and output voltages of the respective sensors **11**, **12**, **13** is identical to that of a case of normal rotation of the rotor **62**.

(54) A subsequent section indicates, by a solid line **515**, a digital signal of the main sensor **11** that is output by the comparator **22**. Changes to an H level and an L level are caused at timings P**0**, P**10** that are zero cross points for the main sensor **11**. A subsequent section indicates, by a solid line **516**, the digital signal **1** where a phase thereof is advanced by 120 degrees relative to a digital signal **515** of the main sensor **11**. A digital signal **516** is produced from an output signal **514** of the auxiliary sensor **13**.

(55) That is, in calibration at a time of motor activation, a level of an output signal of the auxiliary sensor **13** at the timing P**3** that is a point of time when a phase thereof is advanced by 120 degrees relative to an output signal of the main sensor **11** is detected and set as the threshold voltage thB**2**. Furthermore, an output level of an output signal at the timing P**4** when a phase thereof is delayed by 60 degrees relative to the output signal **512** of the main sensor **11** is detected and set as the threshold voltage thB**1**. The digital signal **1** as indicated by the solid line **516** is produced by the comparator **24** where the threshold voltages thB**1**, thB**2** are set.

(56) In a signal production method according to the present embodiment, the digital signal **2** as indicated by a solid line **518** is produced by using the digital signal **515** of the main sensor **11** and the digital signal **1** of the auxiliary sensor **13**. For example, a period of time T**12** is measured that corresponds to a phase difference of 60 degrees between the timing P**18** of falling of the digital signal **515** of the main sensor **11** and the timing P**4** of rising of the digital signal **1** of the auxiliary sensor **13**. Measurement is executed by, for example, a counter (non-illustrated) that is provided in the signal processing part **31**. An arithmetic process is executed in the signal processing part **31** by using the measured period of time T**12** so as to calculate period of times T**13**, T**11**, and T**14** to T**16** that correspond to phase differences of 60 degrees. The digital signal **2** with a phase where the

phase is delayed by 120 degrees relative to the digital signal **515** that is produced depending on the output signal **512** of the main sensor **11** is produced by using the measured period of time T**12** and the calculated periods of time T**11**, T**13** to T**16**. A total value of the periods of time T**11** to T**16** is one cycle of the digital signal **2**. The digital signal **2** is produced in the driving signal production part **35**.
(57) Additionally, although it is also possible to execute an arithmetic process by using only the digital signal **515** of the main sensor **11** so as to produce the digital signal **2** with a phase where the phase is delayed by 120 degrees, it is possible to produce the digital signal **2** that is more accurate, by also using information of the auxiliary sensor **13**.
(58) In a signal production method according to the present embodiment, an auxiliary sensor that produces the digital signal **1** depending on a direction of rotation of the rotor **62** is selected and timings when H/L of the digital signal **1** is switched are timings before output signals of the auxiliary sensor reach a peak value and a bottom value, so that it is possible to simplify a circuit configuration for producing the digital signal **1** from the output signals of the auxiliary sensor.
(59) For example, it is possible to provide the comparator **24** that outputs the digital signal **516** from the auxiliary sensor **13** and is composed of a window comparator that compares the output signal **514** of the auxiliary sensor **13** with the two threshold voltages thB**1**, thB**2**. A method that produces the driving signals HU, LU, HV, LV, HW, LW by using the digital signal **515** of the main sensor **11**, the digital signal **516** of the auxiliary sensor **13**, and a digital signal **518** is similar to that of a case of an embodiment of FIG. **3** and hence is omitted.
(60) A signal production method in a case where a phase difference between output signals of the main sensor **11** and the auxiliary sensor **12** at a time of normal rotation of the rotor **62** is a threshold or less will be explained by using FIG. **6** and FIG. **7**. FIG. **7** is a diagram that enlarges and illustrates a top section to a third section of FIG. **6**.
(61) In calibration at a time of activation of the motor **60**, a phase difference between the output signal **502** of the main sensor **11** and the output signal **503** of the auxiliary sensor **12** at a time of normal rotation of the rotor **62** is compared with a predetermined threshold. That is, a phase difference θ1 between the output signal **502** of the main sensor **11** as indicated in second sections of FIG. **6** and FIG. **7** and the output signal **503** of the auxiliary sensor **12** as indicated in third sections thereof is detected and compared with a threshold. A threshold is, for example, 30 degrees.
(62) As enlarged and illustrated in FIG. **7**, the phase difference θ1 between output signals of the main sensor **11** and the auxiliary sensor **12** is detected by a phase difference between a timing PU when the output signal **502** of the main sensor **11** is provided at a peak value and a timing PU**12** when the output signal **503** of the auxiliary sensor **12** is provided at a peak value or a phase difference between a timing PB when the output signal **502** of the main sensor **11** is provided at a bottom value and a timing PB**12** when the output signal **503** of the auxiliary sensor **12** is provided at a bottom value.
(63) The timing PB when the output signal **502** of the main sensor **11** is provided at a bottom value is present at a position where the timing P**18** that is advanced by 90 degrees relative to an angle of rotation of the main sensor **11** is 180 degrees. Therefore, in a case where the phase difference θ1 is 30 degrees or less, the timing P**1** of the output signal **503** of the auxiliary sensor **12** that is advanced by 120 degrees relative to the timing P**0** when the output signal **502** of the main sensor **11** is zero is present at a predetermined position before reaching the timing PB**12** when the output signal **503** of the auxiliary sensor **12** is provided at a bottom value. Similarly, the timing P**2** when a phase of the output signal **503** of the auxiliary sensor **12** is delayed by 60 degrees relative to the timing P**0** when the output signal **502** of the main sensor **11** is zero is present at a predetermined position before reaching the timing PU**12** when the output signal **503** of the auxiliary sensor **12** is provided at a peak value.
(64) Therefore, it is possible to detect rotational positions of the rotor **62** at the timing P**1** where a phase thereof is advanced by 120 degrees relative to the timing P**18** when an angle of rotation of

the main sensor **11** is 180 degrees and the timing P**2** when a phase thereof is delayed by 60 degrees relative thereto, by a configuration where the output signal **503** of the auxiliary sensor **12** is compared with the threshold voltages thA**1**, thA**2** that are set at a time of calibration. For example, it is possible to provide the comparator **23** that is composed of a window comparator that compares the output signal **503** of the auxiliary sensor **12** with the two threshold voltages thA**1**, thA**2**.

(65) It is possible to produce the digital signal **2** as indicated by the solid line **508** in a bottom section of FIG. **6** as a signal with a phase that is delayed by 120 degrees where T**1** to T**6** are produced by using the digital signal **505** of the main sensor **11** and the digital signal **1** of the auxiliary sensor **12** similarly to a case of FIG. **4**. A method that produces the driving signals HU, LU, HV, LV, HW, LW by using the digital signal **505** of the main sensor **11**, the digital signal **1** that is produced from the output signal **502** of the auxiliary sensor **12**, and the digital signal **2** is similar to that of an example of FIG. **3** and hence is omitted.

(66) A signal production method in a case where a phase difference between an output signal of the main sensor **11** and an output signal of the auxiliary sensor **12** at a time of normal rotation of the rotor **62** is greater than a threshold will be explained by using FIG. **8** and FIG. **9**. FIG. **9** is a diagram that enlarges and illustrates a top section to a third section of FIG. **8**.

(67) The timing PB when the output signal **502** of the main sensor **11** is provided at a bottom value is positioned at a timing that is advanced by 90 degrees relative to the timing P**18** when an angle of rotation of the main sensor **11** is 180 degrees, and the timing PU when it is provided at a peak value is positioned at a timing that is delayed by 90 degrees relative thereto. Therefore, in a case where a phase difference θ2 between the timing PU when the output signal **502** of the main sensor **11** is provided at a peak value and a timing PU**14** when an output signal **523** of the auxiliary sensor **12** is provided at a peak value or between the timing PB when the output signal **502** of the main sensor **11** is provided at a bottom value and a timing PB**14** when that of the auxiliary sensor **12** is provided at a bottom value is greater than 30 degrees, a timing P**14** of an output signal **524** of the auxiliary sensor **13** that is advanced by 60 degrees relative to the timing P**0** when the output signal **502** of the main sensor **11** is zero is present at a predetermined position before reaching a timing PB**13** when the output signal **524** of the auxiliary sensor **13** is provided at a bottom value. Similarly, a timing P**13** when a phase of the output signal **524** of the auxiliary sensor **13** is delayed by 120 degrees relative to the timing P**0** when the output signal **502** of the main sensor **11** is zero is present at a predetermined position before reaching a timing PU**13** when the output signal **524** of the auxiliary sensor **13** reaches a peak value.

(68) Therefore, in a case where a phase difference is greater than 30 degrees, the auxiliary sensor **13** is selected and the output signal **524** of the auxiliary sensor **13** is compared with the threshold voltages thB**1**, thB**2** that are set at a time of calibration, so that it is possible to detect rotational positions of the rotor **62** at the timing P**14** when a phase thereof is advanced by 60 degrees relative to the timing P**18** when an angle of rotation of the main sensor **11** is 180 degrees and the timing P**13** when a phase thereof is delayed by 120 degrees relative thereto. A configuration where a bottom value and a peak value of the output signal **524** of the auxiliary sensor **13** are detected does not have to be provided, so that it is possible to simplify a circuit configuration. For example, it is possible to provide the comparator **24** that obtains a digital signal **526** from the auxiliary sensor **13** and is composed of a window comparator that compares the output signal **524** of the auxiliary sensor **13** with the two threshold voltages thB**1**, thB**2**.

(69) In a case where the phase difference θ2 between output signals of the main sensor **11** and the auxiliary sensor **12** is greater than a threshold of 30 degrees, the digital signal **1** is produced by using the output signal **524** of the auxiliary sensor **13**. It is possible to produce the digital signal **2** as indicated by a solid line **528** as a signal with a phase that is delayed by 120 degrees relative to the digital signal **1** by executing an arithmetic process of the digital signal **1**. Additionally, similarly to a case of FIG. **4**, the digital signal **2** may be produced by measuring a time that corresponds to a phase difference of 60 degrees relative to the digital signal **1** of the auxiliary sensor **13** by also

using information of a digital signal **525** of the main sensor **11**, and executing an arithmetic process by using such a measurement value.
(70) Additionally, as described, the auxiliary sensors **12**, **13** are arranged at line-symmetric positions relative to the main sensor **11**, so that a phase difference that is identical to the phase difference θ2 between output signals of the main sensor **11** and the auxiliary sensor **12** is produced between the output signal **502** of the main sensor **11** and the output signal **524** of the auxiliary sensor **13**.
(71) FIG. **10** is a diagram for explaining signal production in a case where an offset is present in output signals of the auxiliary sensors **12**, **13**. An example of a case where an offset offset is present in an output signal **533** of the auxiliary sensor **12** at a time of normal rotation of the rotor **62** is provided. As described, the threshold voltages thA**1**, thA**2** are set based on values of the output signal **533** of the auxiliary sensor **12** at the predetermined timings P**1**, P**2** that are acquired in calibration that is executed at a time of motor activation. A value of the output signal **533** of the auxiliary sensor **12** at the timing P**1** that is advanced by 120 degrees relative to a rotational angle of the rotor **62** that is 180 degrees is set as the threshold voltage thA**1** and a value of the output signal **533** at the timing P**2** at an angle of rotation that is delayed by 60 degrees relative thereto is set as the threshold voltage thA**2**. The digital signal **1** that is indicated by a solid line **536** is produced depending on results of comparison of the output signal **533** of the auxiliary sensor **12** with the threshold voltages thA**1**, thA**2**. The digital signal **2** that is indicated by a solid line **538** is produced by using a digital signal **535** that is produced from the output signal **502** of the main sensor **11**.
(72) In the present embodiment, the threshold voltages thA**1**, thA**2** are set depending on an offset offset of the auxiliary sensor **12**. Similarly, the threshold voltages thB**1**, thB**2** of the comparator **24** where an output signal **534** of the auxiliary sensor **13** is supplied thereto are also set by the output signal **534** that is dependent on an offset of the auxiliary sensor **13**. It is possible to set the threshold voltages thA**1**, thA**2**, thB**1**, thB**2** of the comparators **23**, **24** depending on an offset, so that an offset cancel part does not have to be provided for the auxiliary sensor **12**, **13**. Therefore, it is possible to simplify a circuit configuration. Additionally, similarly to a case of FIG. **4**, the digital signal **2** may be produced by measuring a time that corresponds to a phase difference of 60 degrees relative to the digital signal **1** of the auxiliary sensor **12** by also using information of the digital signal **535** of the main sensor **11**, and executing an arithmetic process by using such a measurement value.
(73) FIG. **11** is a diagram that illustrates a flow of one embodiment of calibration. The motor **60** is normally rotated at a constant frequency forcibly (S**10**). A driving signal with a predetermined pattern that normally rotates the motor **60** at a constant frequency (rotational frequency) forcibly is produced in the driving signal production part **35** and is supplied to the respective output transistors **41** to **46** of the output circuit part **40**. Original data of a predetermined pattern are stored in, for example, the memory part **50** and are supplied to the driving signal production part **35** at a predetermined timing through the signal processing part **31**. Original data may be supplied from an outside of the driving device **100**.
(74) A phase difference between an output signal of the main sensor **11** and an output signal of the auxiliary sensor **12** is detected (S**11**). For example, a phase difference between peak values of output signals of the main sensor **11** and the auxiliary sensor **12** is detected. A phase difference between peak values is detected, so that, for example, it is possible to exclude an influence in a case where an offset is present in an output signal of the auxiliary sensor **12**.
(75) Whether or not a phase difference is 30 degrees that is a threshold or less is determined (S**12**). In a case where a phase difference is 30 degrees or less (S**12**: Yes), the auxiliary sensor **12** is selected (S**13**). That is, the auxiliary sensor **12** that is advanced at a time of normal rotation of the rotor **62** is selected and an output level of an output signal of the auxiliary sensor **12** with a phase that is advanced by 120 degrees relative to an output signal of the main sensor **11** is detected (S**15**).
(76) In a case where a phase difference is greater than 30 degrees (S**12**: No), the auxiliary sensor **13** is selected (S**14**). That is, the auxiliary sensor **13** that follows the main sensor **11** at a time of

normal rotation of the rotor **62** is selected and an output level of an output signal of the auxiliary sensor **13** with a phase that is delayed by 120 degrees relative to an output signal of the main sensor **11** is detected (S**16**).

(77) A result of selection and an output level of an auxiliary sensor at a time of normal rotation of the rotor **60** are stored in a memory of the memory part **50** (S**17**). A stored detection level is set as a threshold voltage of a comparator.

(78) Then, the motor **60** is reversely rotated at a constant frequency forcibly (S**18**). Control is executed in such a manner that a driving signal with a predetermined pattern that reversely rotates the motor **60** at a constant frequency (rotational frequency) forcibly is produced in the driving signal production part **35** and is supplied to the respective output transistors **41** to **46** of the output circuit part **40**. Original data that are provided as a base of a predetermine pattern are stored in the memory part **50** and are supplied to the driving signal production part **35** at a predetermined timing through the signal processing part **31**. A reason why a step of executing reverse rotation forcibly is provided is to prepare for a case where the motor **60** is reversely rotated.

(79) In a case where the auxiliary sensor **12** is selected at a time of normal rotation of the rotor **60** (S**19**: Yes), that is, a case where a phase difference between output signals of the main sensor **11** and the auxiliary sensor **12** is 30 degrees or less, the auxiliary sensor **13** is selected (S**20**) and an output level of an output signal of the auxiliary sensor **13** with a phase that is advanced by 120 degrees relative to an output of the main sensor **11** is detected (S**22**). Thereby, as explained in FIG. **5**, a detection level (thB**2**) at the timing P**3** before an output level of an output signal of the auxiliary sensor **13** reaches a peak value and an output level (thB**1**) of an output signal at the timing P**4** before it reaches a bottom value are detected, so that it is possible to detect them as setting values of threshold voltages of the comparator **24**.

(80) In a case where the auxiliary sensor **12** is not selected at a time of normal rotation of the motor **60** (S**19**: No), the auxiliary sensor **12** is selected (S**21**) and an output level of an output signal of the auxiliary sensor **12** with a phase that is delayed by 120 degrees relative to an output of the main sensor **11** is detected (S**23**). Thereby, it is possible to detect a value before an output level of an output signal of the auxiliary sensor **12** reaches a bottom value and a value before it reaches a peak value, as setting values of the threshold voltages thA**1**, thA**2** of the comparator **23**.

(81) A result of selection and an output level of an auxiliary sensor at a time of reverse rotation of the motor are stored in a memory of the memory part **50** (S**24**). Stored output levels are set as the threshold voltages thA**1**, thA**2**, thB**1**, thB**2** of the comparators **23**, **24**.

(82) For example, calibration is automatically executed at a time of motor activation, so that threshold voltages of the respective comparators **23**, **24** are set. Output signal of the respective auxiliary sensors **12**, **13** are compared with respective threshold voltages so as to detect timings when the respective threshold voltages are reached, so that it is possible to detect a rotational position of the rotor **62**. Additionally, a driving signal in calibration at a time of activation may be supplied from an outside of the driving device **100** to the output circuit part **40**.

(83) FIG. **12** is a diagram that illustrates an example of a plane pattern where the driving device **100** is integrated. In the driving device **100**, the main sensor **11**, the auxiliary sensors **12**, **13**, the detection part **20**, the control part **30**, the output circuit part **40**, and the memory part **50** are integrally integrated. The auxiliary sensors **12**, **13** are formed on both sides of the main sensor **11**. The auxiliary sensors **12**, **13** are provided on both sides of the main sensor **11**, so that it is possible to provide a configuration where a rotational position of the rotor **62** is detected so as to precede or follow the main sensor **11** depending on rotation of the rotor **62**.

(84) In a case where the main sensor **11** and the auxiliary sensors **12**, **13** are formed of silicon, for example, it is possible to form it on a single silicon substrate integrally together with the detection part **20**, the control part **30**, the output circuit part **40**, and the memory part **50** and integrally integrate them by a mold resin.

(85) In a case where Hall elements that compose the respective sensors **11**, **12**, **13** are composed of

a compound semiconductor, it is possible to integrate separate chips (non-illustrated) where Hall elements that are composed of a compound semiconductor are formed, with a silicon substrate where other circuit parts are formed, by a multichip configuration, and integrally integrate them by, for example, a mold resin. Furthermore, a part of components may be composed of other integrated circuits as external ones. For example, the output transistors **41** to **46** that compose the output circuit part **40** are composed of high-voltage Double Diffused MOS (DMOS) transistors and are involved with heat generation, so that they may be configured as an external integrated circuit device.
(86) FIG. **13** is an exploded perspective view of one embodiment of a motor that incorporates the driving device **100**. The driving device **100** is mounted on a support base **200**. An exciting coil (non-illustrated) is provided on a stator **202** and an exciting current is supplied thereto through the output lines **301** to **303**.
(87) The rotor **62** that is composed of a permanent magnet, the stator **202**, and the support base **200** are housed by an upper housing **201** and a lower housing **203**.
(88) A configuration where the driving device **100** is provided in such a manner that the main sensor **11** and the auxiliary sensors **12**, **13** are integrally integrated is provided, so that it is possible to eliminate a right side part **200**A of the support base **200** as indicated by a dotted line. Thereby, it is possible to reduce a cost of a motor. For example, it is possible to divide a flat plate with a ring shape (non-illustrated) into halves so as to provide semi-ring shapes, use one of them as the support base **200**, and use the other as a support base of another motor. The driving device **100** where the main sensor **11** and the auxiliary sensors **12**, **13** are integrally integrated is provided, so that it is possible to reduce a cost of a motor.
(89) Although a case where the rotor **62** is of two poles has been explained in an embodiment as described, it is possible to detect a rotational position of the rotor **62** by similarly using the driving device **100** even in a case where the rotor **62** is of four poles, eight poles, or the like.
(90) Although some embodiments of the present invention have been explained, these embodiments are presented as examples and do not intend to limit the scope of the invention. These novel embodiments are capable of being implemented in various other modes and it is possible to execute a variety of omissions, substitutions, and modifications without departing from the spirit of the invention. These embodiments and/or variations thereof are included in the scope and/or spirit of the invention and are included in the scope of the invention as recited in what is claimed and equivalents thereof.

Claims

1. A brushless motor driving device comprising: an output part that supplies an excitation current to an excitation coil that generates a magnetic field that rotates a rotor; a position detection part including a first detection element, a second detection element, and a third detection element, each being disposed to face the rotor, the position detection part detecting a rotational position of the rotor on the basis of output signals from the first to third detection elements, the output signals being output in response to approaching part of the rotor having a specific magnetic pole; and a driving control part that produces a driving signal based on a detection signal from the position detection part and supplies the driving signal to the output part, wherein the first to third detection elements and the driving control part are integrally provided on a surface of a substrate, the second detection element is provided at a position where the second detection element outputs the output signal preceding the output signal from the first detection element, the third detection element is provided at a position where the third detection element outputs the output signal following the output signal from the first detection element, and the driving control part, at a time of normal rotation of the rotor, produces the driving signal by using a detection signal of the first detection element and a detection signal of the second detection element in a case where a phase difference

between the detection signal of the first detection element and the detection signal of the second detection element is a predetermined threshold or less, or produces the driving signal by using a detection signal of the first detection element and a detection signal of the third detection element in a case where a phase difference between the detection signal of the first detection element and the detection signal of the second detection element is greater than the predetermined threshold.

2. The brushless motor driving device according to claim 1, wherein the first detection element is provided at a position where a first center line passing through a center of the first detection element passes through a center of the rotor, and the second detection element and the third detection element are provided at line-symmetric positions relative to the first center line.

3. The brushless motor driving device according to claim 2, wherein the second detection element and the third detection element are provided at positions where a first angle and a second angle with respect to the first center line are equal to one another, the first angle is an angle between the first center line and a second center line, the second center line passing through a center of the second detection element and the center of the rotor, and the second angle is an angle between the first center line and a third center line, the third center line passing through a center of the third detection element and the center of the rotor.

4. The brushless motor driving device according to claim 1, wherein the predetermined threshold is 30 degrees.

5. The brushless motor driving device according to claim 1, wherein the driving control part produces the driving signal by using the detection signal of the first detection element and the detection signal of the third detection element at a time of reverse rotation of the rotor, in a case where the driving signal is produced by using the detection signal of the first detection element and the detection signal of the second detection element at a time of normal rotation of the rotor.

6. The brushless motor driving device according to claim 1, further comprising a threshold voltage production part that sets detection levels for a detection signal of the second detection element and a detection signal of the third detection element.

7. The brushless motor driving device according to claim 6, further comprising: a first comparator that compares a level of a detection signal of the second detection element and the detection level that is set by the threshold voltage production part for the detection signal of the second detection element; and a second comparator that compares a level of a detection signal of the third detection element and the detection level that is set by the threshold voltage production part for the detection signal of the third detection element.

8. The brushless motor driving device according to claim 1, further comprising an offset cancel part that is provided on the first detection element, wherein the first to third detection elements and the driving control part are integrated by a mold resin.

9. A brushless motor comprising: a rotor; a brushless driving device including an output part that supplies an excitation current to an excitation coil that generates a magnetic field that rotates the rotor, a position detection part including a first detection element, a second detection element, and a third detection element, each being disposed to face the rotor, the position detection part detecting a rotational position of the rotor on the basis of output signals from the first to third detection elements, the output signals being output in response to approaching part of the rotor having a specific magnetic pole, and a driving control part that produces a driving signal based on a detection signal from the position detection part and supplies the driving signal to the output part; and a support base that supports the brushless driving device, the support base being composed of a flat plate with a semi-ring shape, wherein the first to third detection elements and the driving control part are integrally provided on a surface of a substrate, the second detection element is provided at a position where the second detection element outputs the output signal preceding the output signal from the first detection element, and the third detection element is provided at a position where the third detection element outputs the output signal following the output signal from the first detection element.

10. The brushless motor according to claim 9, wherein the first detection element is provided at a position where a first center line passing through a center of the first detection element passes through a center of the rotor, and the second detection element and the third detection element are provided at line-symmetric positions relative to the first center line.
11. The brushless motor according to claim 10, wherein the second detection element and the third detection element are provided at positions where a first angle and a second angle with respect to the first center line are equal to one another, the first angle is an angle between the first center line and a second center line, the second center line passing through a center of the second detection element and the center of the rotor, and the second angle is an angle between the first center line and a third center line, the third center line passing through a center of the third detection element and the center of the rotor.
12. The brushless motor according to claim 9, further comprising an offset cancel part that is provided on the first detection element.
13. A brushless motor driving device comprising: an output part that supplies an excitation current to an excitation coil that generates a magnetic field that rotates a rotor; a position detection part including a first detection element, a second detection element, and a third detection element, each being disposed to face the rotor, the position detection part detecting a rotational position of the rotor on the basis of output signals from the first to third detection elements, the output signals being output in response to approaching part of the rotor having a specific magnetic pole; a driving control part that produces a driving signal based on a detection signal from the position detection part and supplies the driving signal to the output part; and a memory part that holds values of detection signals of the second and third detection elements that are obtained in calibration where the rotor is rotated under a preliminarily set condition, wherein the first to third detection elements and the driving control part are integrally provided on a surface of a substrate, the second detection element is provided at a position where the second detection element outputs the output signal preceding the output signal from the first detection element, and the third detection element is provided at a position where the third detection element outputs the output signal following the output signal from the first detection element.
14. The brushless motor driving device according to claim 13, wherein the first detection element is provided at a position where a first center line passing through a center of the first detection element passes through a center of the rotor, and the second detection element and the third detection element are provided at line-symmetric positions relative to the first center line.
15. The brushless motor driving device according to claim 14, wherein the second detection element and the third detection element are provided at positions where a first angle and a second angle with respect to the first center line are equal to one another, the first angle is an angle between the first center line and a second center line, the second center line passing through a center of the second detection element and the center of the rotor, and the second angle is an angle between the first center line and a third center line, the third center line passing through a center of the third detection element and the center of the rotor.
16. The brushless motor driving device according to claim 13, wherein the driving control part, at a time of normal rotation of the rotor, produces the driving signal by using a detection signal of the first detection element and a detection signal of the second detection element in a case where a phase difference between the detection signal of the first detection element and the detection signal of the second detection element is a predetermined threshold or less, or produces the driving signal by using a detection signal of the first detection element and a detection signal of the third detection element in a case where a phase difference between the detection signal of the first detection element and the detection signal of the second detection element is greater than the predetermined threshold.
17. The brushless motor driving device according to claim 16, wherein the predetermined threshold is 30 degrees.

18. The brushless motor driving device according to claim 16, wherein the driving control part produces the driving signal by using the detection signal of the first detection element and the detection signal of the third detection element at a time of reverse rotation of the rotor, in a case where the driving signal is produced by using the detection signal of the first detection element and the detection signal of the second detection element at a time of normal rotation of the rotor.

19. The brushless motor driving device according to claim 13, further comprising a threshold voltage production part that sets detection levels for a detection signal of the second detection element and a detection signal of the third detection element.

20. The brushless motor driving device according to claim 19, further comprising: a first comparator that compares a level of a detection signal of the second detection element and the detection level that is set by the threshold voltage production part for the detection signal of the second detection element; and a second comparator that compares a level of a detection signal of the third detection element and the detection level that is set by the threshold voltage production part for the detection signal of the third detection element.

21. The brushless motor driving device according to claim 13, further comprising an offset cancel part that is provided on the first detection element, wherein the first to third detection elements and the driving control part are integrated by a mold resin.