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Camera module, portable electronic device, and position control system

Abstract

Provided is a camera module, comprising a controller including a first position control unit generating a first position control signal indicating a first target position to which an object provided with an image sensor or a lens is to be moved, and a first master port outputting the first position control signal, a first driver including a first slave port connected to the first master port, a first driving unit providing driving force to the object based on the first position control signal, a second position control unit generating a second position control signal indicating a second target position to which the object is to be moved, and a second master port outputting the second position control signal, and a second driver including a second slave port connected to the second master port, a second driving unit providing driving force to the object based on the second position control signal.

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Background/Summary

(1) The contents of the following Japanese patent application(s) are incorporated herein by reference: NO. 2021-185978 filed in JP on Nov. 15, 2021

BACKGROUND

1. Technical Field

(2) The present invention relates to a camera module, a portable electronic device, and a position control system.

2. Related Art

(3) Patent document 1 describes that “a single master port M disposed on an OIS controller 221 is connected to slave ports S each disposed on a first OIS driver 222a and a second OIS driver 222b”.

PRIOR ART DOCUMENT

Patent Document

(4) [Patent document 1] Specification of U.S. Pat. No. 11,039,071

SUMMARY

(5) In a first aspect of the present invention, a camera module is provided. The camera module may include a controller including a first position control unit configured to generate a first position control signal indicating a first target position to which an object provided with an image sensor or a lens is to be moved, and a first master port configured to output the first position control signal. The camera module may include a first driver including a first slave port connected to the first master port, a first driving unit configured to provide driving force to the object based on the first position control signal, a second position control unit configured to generate a second position control signal indicating a second target position to which the object is to be moved, and a second

master port configured to output the second position control signal. The camera module may include a second driver including a second slave port connected to the second master port, and a second driving unit configured to provide driving force to the object based on the second position control signal.

(6) The first driver may further include a first sensor configured to detect a position of the object. The first driving unit may be configured to provide driving force to the object based on a first position signal indicating a position of the object detected by the first sensor, and the first position control signal.

(7) The second driver may further include a second sensor configured to detect a position of the object. The second driving unit may provide driving force to the object based on a second position signal indicating a position of the object detected by the second sensor, and the second position control signal.

(8) The first driver may further include a calculating unit configured to correct at least any of the first position control signal, the first position signal, and the second position control signal at least based on the second position signal obtained via the second master port.

(9) The calculating unit may be configured to correct at least any of the first position control signal, the first position signal, and the second position control signal in such a way so as to reduce mutual interference by drive of the object by the first driver and drive of the object by the second driver.

(10) When the first driver is configured to drive a first object provided with a first lens, and the second driver is configured to drive a second object provided with a second lens, the calculating unit may be configured to correct at least any of the first position control signal, the first position signal, and the second position control signal in such a way so that the first object and the second object interlock.

(11) In a second aspect of the present invention, a camera module is provided. The camera module may include a controller including a position control unit configured to generate a position control signal indicating a target position to which an object provided with a lens is to be moved, and a first master port configured to output the position control signal. The camera module may include a driver including a first slave port connected to the first master port, a second master port to which a position detector has a slave connection, and a driving unit configured to provide driving force to the object based on position information indicating a position of the object detected by the position detector, and the position control signal.

(12) The driver may further include a sensor configured to detect a position of the object. The driving unit may be configured to provide driving force to the object based on a position signal indicating a position of the object detected by the sensor, the position information, and the position control signal.

(13) The driver may further include a calculating unit configured to correct tilt in relation to an optical axis of the lens in the object based on the position information.

(14) In the camera module, communication between master and slave may be serial communication.

(15) The camera module may be capable of executing at least any of optical image stabilization, auto focus, and zoom processes.

(16) In the second aspect of the present invention, a portable electronic device is provided. The portable electronic device may include a controller including a first position control unit configured to generate a first position control signal indicating a first target position to which an object provided with an image sensor or a lens is to be moved, and a first master port configured to output the first position control signal. The portable electronic device may include a first driver including a first slave port connected to the first master port, a first driving unit configured to provide driving force to the object based on the first position control signal, a second position control unit configured to generate a second position control signal indicating a second target position to which the object is to be moved, and a second master port configured to output the second position

control signal. The portable electronic device may include a second driver including a second slave port connected to the second master port, a second driving unit configured to provide driving force to the object based on the second position control signal.
(17) In a third aspect of the present invention, a position control system is provided. The position control system may include a controller including a first position control unit configured to generate a first position control signal indicating a first target position to which an object provided with an image sensor or a lens is to be moved, and a first master port configured to output the first position control signal. The position control system may include a first driver including a first slave port connected to the first master port, a first driving unit configured to provide driving force to the object based on the first position control signal, a second position control unit configured to generate a second position control signal indicating a second target position to which the object is to be moved, and a second master port configured to output the second position control signal. The position control system may include a second driver including a second slave port connected to the second master port, a second driving unit configured to provide driving force to the object based on the second position control signal.
(18) The summary clause does not necessarily describe all necessary features of the embodiments of the present invention. In addition, the present invention may also be a sub-combination of the features described above.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** shows an example of a block diagram of a camera module **10** according to a first embodiment.
(2) FIG. **2** shows an example of a block diagram of the controller **100**.
(3) FIG. **3** shows an example of a block diagram of the first driver **200**.
(4) FIG. **4** shows an example of a block diagram of the second driver **300**.
(5) FIG. **5** shows an example of a timing diagram of the camera module **10** according to the first embodiment.
(6) FIG. **6** shows an example of a block diagram of the camera module **10** according to a second embodiment.
(7) FIG. **7** shows an example of a timing diagram of the camera module **10** according to the second embodiment.
(8) FIG. **8** shows an example of a block diagram of the camera module **10** according to a third embodiment.
(9) FIG. **9** shows an example of a timing diagram of the camera module **10** according to the third embodiment.
(10) FIG. **10** shows an example of a block diagram of the camera module **10** according to a fourth embodiment.
(11) FIG. **11** shows an example of a block diagram of the camera module **10** according to a fifth embodiment.
(12) FIG. **12** shows an example of a block diagram of the camera module **10** according to a sixth embodiment.
(13) FIG. **13** shows an example of a block diagram of the camera module **10** according to a seventh embodiment.
(14) FIG. **14** shows an example of a timing diagram of the camera module **10** according to the seventh embodiment.
(15) FIG. **15** shows an example of a block diagram of the camera module **10** according to an eighth embodiment.

(16) FIG. **16** shows an example of a timing diagram of the camera module **10** according to the eighth embodiment.
(17) FIG. **17** shows an example of a block diagram of the camera module **10** according to a ninth embodiment.
(18) FIG. **18** shows a first example of a timing diagram of the camera module **10** according to the ninth embodiment.
(19) FIG. **19** shows a second example of a timing diagram of the camera module **10** according to the ninth embodiment.
(20) FIG. **20** shows an example of a block diagram of the camera module **10** according to a tenth embodiment.
(21) FIG. **21** shows an example of a timing diagram of the camera module **10** according to the tenth embodiment.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

(22) In the following, the present invention will be described through embodiments of the invention, but the following embodiments do not limit the invention according to the scope of claims. In addition, not all of the combinations of features described in the embodiments are essential to the solving means of the invention.
(23) FIG. **1** shows an example of a block diagram of a camera module **10** according to a first embodiment. It is noted that these blocks are function blocks each separated by function, and they may not necessarily match the actual device configuration. That is, in the present drawing, even if it is shown as one block, it may not necessarily be configured by one device. In addition, in the present drawing, even if they are shown as different blocks, they may not necessarily be configured by different devices. The same can be said for other drawings.
(24) In addition, hereinafter, the camera module **10** is described as an example, but it is not limited to this. A portable electronic device or a position control system including a similar function to that of the camera module **10** described in the following may be provided. Such things include, for example, a cell phone, a smart phone, a tablet device, a PDA, a portable computer, a laptop, and a notebook personal computer, or an external system for controlling a position of an object.
(25) The camera module **10** may be capable of executing at least any of optical image stabilization, auto focus, and zoom processes. In this case, in the camera module **10**, a controller does not centrally control a plurality of drivers alone, but at least one driver is also for performing a function as a sub-controller, and the controller and the sub-controller work together to separately control the plurality of drivers. In the first embodiment, a case where the camera module **10** executes a lens shift type optical image stabilization (OIS) process is described.
(26) The camera module **10** includes an object **20**, a first coil **50_1** and a second coil **50_2** (generically referred to as “coils **50**”), a controller **100**, a first driver **200**, and a second driver **300**.
(27) The object **20** is a device that changes position according to an input signal. Hereinafter, a case where the object **20** is a lens barrel will be described as an example. In the present embodiment, the object **20** is provided with a lens **30**, a first magnet **40_1** and a second magnet **40_2** (generically referred to as magnets **40**).
(28) The lens **30** is an optical element for refracting and focusing light. In the lens shift type OIS process, by moving the object **20** and shifting the lens **30**, the optical axis is maintained in the center portion of the image to mitigate video distortion due to camera shake.
(29) The magnets **40** are permanent magnets. In the present embodiment, the first magnet **40_1** is disposed along an x axis direction. In addition, the second magnet **40_2** is disposed along a y axis direction.
(30) The coils **50** are wound along a certain direction. In the present embodiment, the first coil **50_1**, nearby the first magnet **40_1**, is wound along the x axis direction similarly to the first magnet **40_1**. In addition, the second coil **50_2**, nearby the second magnet **40_2**, is wound along the y axis direction similarly to the second magnet **40_2**. When a driving current is supplied to such the first

coil **50_1** and the second coil **50_2**, since a magnetic force is respectively generated between the first coil **50_1** and the first magnet **40_1** and between the second coil **50_2** and the second magnet **40_2**, the object **20** is displaced. In this way, it is possible to correct a two axis blur.

(31) The controller **100** is a high-order controller for controlling a driver. In the present embodiment, the controller **100** may be an OIS controller. In the present embodiment, the controller **100** has a master connection in relation to the first driver **200**, and outputs a generated first position control signal to the first driver **200**.

(32) The first driver **200** is a driver for providing driving force to the object **20**. In the present embodiment, the first driver **200** may be an OIS driver. The first driver **200** has a slave connection in relation to the controller **100**, and supplies a driving current to the first coil **50_1** based on the first position control signal output from the controller **100**. In addition, the first driver **200** is also for performing a function as a sub-controller. That is, the first driver **200** has a master connection in relation to the second driver **300**, and outputs a generated second position control signal to the second driver **300**.

(33) The second driver **300** is a driver for providing driving force to the object **20**. In the present embodiment, the second driver **300** may be an OIS driver. The second driver **300** has a slave connection in relation to the first driver **200**, and supplies a driving current to the second coil **50_2** based on the second position control signal output from the first driver **200**.

(34) Herein, in the present embodiment, the communication path between the controller **100** and the first driver **200** is defined as a first communication bus, and the communication path between the first driver **200** and the second driver **300** is defined as a second communication bus. Communication between master and slave in such the first communication bus and the second communication bus may be, for example, serial communication such as an Inter-Integrated Circuit (I2C). In I2C, in general, one master and one or more slaves are connected in a party line shape by two signal lines, a clock signal line SCL and a data signal line SDA. In addition, each slave has an address, and only one slave designated with the address included in the data communicates one-on-one with the master.

(35) Then, the controller **100**, the first driver **200**, and the second driver **300** will each be described in detail.

(36) FIG. **2** shows an example of a block diagram of the controller **100**. The controller **100** includes a high-order slave port **110**, a high-order master port **120**, a first position control unit **130**, and a first master port **140**.

(37) The high-order slave port is connected to a master port of a host (not shown). Such a host may be, for example, an Image Signal Processor (ISP). The ISP is an image processor in a camera system. The controller **100** obtains a high-order control signal from the host via the said high-order slave port **110**. The obtained high-order control signal is supplied to the first position control unit **130**.

(38) The high-order master port **120** is connected to a slave port of a gyro sensor (not shown). The controller **100** obtains a gyro signal from the gyro sensor via the said high-order master port **120**. The obtained gyro signal is supplied to the first position control unit **130**.

(39) The first position control unit **130** generates a first position control signal for indicating a first target position to which the object **20** provided with the lens **30** is to be moved. In the present embodiment, the first position control unit **130** triggers the OIS process based on the high-order control signal. The first position control unit **130** generates the first position control signal for indicating a target position Vt_X in the x axis direction and a target position Vt_Y in the y axis direction based on the gyro signal. The first position control unit **130** supplies the generated first position control signal to the first master port **140**.

(40) The first master port **140** is connected to a slave port in the first driver **200**. The first master port **140** outputs the first position control signal generated by the first position control unit **130** to the first driver **200**.

(41) FIG. **3** shows an example of a block diagram of the first driver **200**. The first driver **200** includes a first slave port **210**, a first sensor **220**, a first driving unit **230**, a second position control unit **240**, a second master port **250**, and a calculating unit **260**.
(42) The first slave port **210** is connected to the first master port **140** in the controller **100**. The first driver **200** obtains the first position control signal from the controller **100** via the said first slave port **210**. The obtained first position control signal is supplied to the first driving unit **230**, the second position control unit **240**, and the calculating unit **260**.
(43) The first sensor **220** detects a position of the object **20**. The first sensor **220** may be, for example, a magnetic sensor, and may detect the position of the object **20** by detecting a magnetic field that is generated from the first magnet **40_1** provided on the object **20**. Such a magnetic sensor, as an example, may be a hall sensor for providing a hall effect and detecting a change in an external magnetic field from a generated electromotive force. However, it is not limited to this. The magnetic sensor may be various sensors that can detect a magnetic field such as a spin valve type magneto resistive sensor (such as GMR element, TMR element) for changing resistance according to change in the external magnetic field, and may be a combination of these various sensors. In addition, the first sensor **220** may be configured by a sensor element group made up of a plurality of sensor elements. The first sensor **220** supplies the first position signal indicating a position Vp_**1** of the detected object **20** to the first driving unit **230** and the calculating unit **260**.
(44) The first driving unit **230** applies driving force to the object **20** based on the first position control signal. In this case, as an example, the first driving unit **230** may execute PID control. Herein, PID control is a type of feedback control, and is a type of control for performing control of an input value by three elements which are a deviation between an output value and a target value, and an integral and a derivative thereof. There is proportional control (P control) as a basic feedback control. This controls the input value as a linear function of the deviation between the output value and the target value. This action for changing the input value in proportion to the deviation is called proportional action, or alternatively, P action (P is an abbreviation of Proportional). That is, if a state with deviation continues for a long time, the change of the input value is increased to bring it closer to the target value. In addition, this action for changing the input value in proportion to the integral of the deviation is called integral action, or alternatively, I action (I is an abbreviation for Integral). In this manner, control in which the proportional action and the integral action are combined is called PI control. In addition, this action for changing the input value in proportion to the derivative of the deviation is called derivative action, or alternatively, D action (D is an abbreviation of Derivative or Differential). Control in which such the proportional action, integral action, and derivative action are combined is called PID control. That is, the first driving unit **230** may provide the driving force to the object **20** by executing PID control based on the first position signal indicating the position of the object **20** detected by the first sensor **220**, and the first position control signal. In more detail, the first driving unit **230** may generate a first control signal for moving the position Vp_**1** of the object **20** indicated by the first position signal to the target position Vt_X in the x axis direction indicated by the first position control signal. The first driving unit **230** may supply a driving current according to the first control signal to the first coil **50_1**.
(45) The second position control unit **240** generates the second position control signal indicating a second target position to which the object is to be moved. In the present embodiment, the second position control unit **240** generates the second position control signal indicating the target position Vt_Y in the y axis direction. In this case, for the target position Vt_Y in the y axis direction, the second position control unit **240** may use what is indicated by the first position control signal as is, and may use the target position Vt_Y that has been corrected by the calculating unit **260** described below. The second position control unit **240** supplies the generated second position control signal to the second master port **250**.
(46) The second master port **250** is connected to a slave port of the second driver **300**. The second

master port **250** outputs the second position control signal generated by the second position control unit **240** to the second driver **300**. In addition, the first driver **200** obtains the second position signal indicating the position of the object **20** that has been detected by a second sensor described below from the second driver **300** via the said second master port **250**. The obtained second position signal is supplied to the calculating unit **260**.

(47) The calculating unit **260** corrects at least any of the first position control signal, the first position signal, and the second position control signal based on at least the second position signal obtained via the second master port **250**. When a two axis blur is corrected by OIS, a drive in one axis may provide mutual interference to a drive in the other axis. For example, when a driving current is supplied to the first coil **50_1** from the first driver **200**, the magnetic field generated by the first coil **50_1** may provide an effect on position detection by the second sensor. In addition, according to this, when the object **20** is displaced, the magnetic field generated by the first magnet **40_1** may provide an effect on the position detection by the second sensor. In the same way, when the driving current is supplied to the second coil **50_2** from the second driver **300**, the magnetic field generated by the second coil **502** may provide an effect on position detection by the first sensor **220**. In addition, according to this, when the object **20** is displaced, the magnetic field generated by the second magnet **40_2** may provide an effect on the position detection by the first sensor **220**. In order to mitigate such an effect, the calculating unit **260** may correct at least any of the first position control signal, the first position signal, and the second position control signal in such a way so as to reduce the mutual interference by the drive of the object **20** by the first driver **200** and the drive of the object **20** by the second driver **300**. The calculating unit **260**, when it has corrected at least any of the first position control signal and the first position signal, notifies said effect to the first driving unit **230**. In this way, the first driving unit **230** executes PID control based on at least any of the corrected first position control signal and the first position signal. In addition, the calculating unit **260**, when it has corrected the second position control signal, notifies said effect to the second position control unit **240**. According to this, the second position control unit **240** supplies the corrected second position control signal to the second master port **250**.

(48) FIG. **4** shows an example of a block diagram of the second driver **300**. The second driver **300** includes a second slave port **310**, a second sensor **320**, and a second driving unit **330**.

(49) The second slave port **310** is connected to the second master port **250** in the first driver **200**. The second driver **300** obtains the second position control signal from the first driver **200** via the said second slave port **310**. The obtained second position control signal is supplied to the second driving unit **330**. In addition, the second slave port **310** outputs the second position signal indicating the position of the object **20** detected by the second sensor **320** to the first driver **200**.

(50) The second sensor **320** detects the position of the object **20**. The second sensor **320** may be similar to the first sensor **220** in the first driver **200**, so its description is omitted herein. The second sensor **320** supplies the second position signal indicating a position Vp_**2** of the detected object to the second slave port **310** and the second driving unit **330**.

(51) The second driving unit **330** applies driving force to the object **20** based on the second position control signal. The second driving unit **330** may be similar to the first driving unit **230** in the first driver **200**. That is, the second driving unit **330** may provide the driving force to the object **20** by executing PID control based on the second position signal indicating the position of the object **20** detected by the second sensor **320** and the second position control signal. In more detail, the second driving unit **330** may generate a second control signal for moving the position Vp_**2** of the object indicated by the second position signal to the target position Vt_Y in the y axis direction indicated by the second position control signal. The second driving unit **330** may supply a driving current according to the second control signal to the second coil **50_2**.

(52) FIG. **5** shows an example of a timing diagram of the camera module **10** according to the first embodiment. The upper part of the present drawing shows a process in connection to the first communication bus in between the controller **100** and the first driver **200**. The lower part of the

present drawing shows a process in connection to the second communication bus in between the first driver **200** and the second driver **300**. In addition, in the present drawing, the horizontal axis indicates time.

(53) First, focusing on the process in connection to the first communication bus (the upper part of the present drawing), at time T**11**, the controller **100** loads the gyro signal obtained from the gyro sensor via the high-order master port **120**. The first position control unit **130** executes OIS calculation based on the gyro signal, and generates the first position control signal indicating the target position Vt_X in the x axis direction and the target position Vt_Y in the y axis direction. The first position control unit **130** supplies the generated first position control signal to the first master port **140**.

(54) At time T**12**, the first master port **140** outputs the first position control signal generated by the first position control unit **130** to the first driver **200**. According to this, the first driver **200** obtains the first position control signal via the first slave port **210**. In this manner, in the period from time T**12** to T**13**, a writing process of data (the target position of the x axis direction and the y axis direction) to the first driver **200** is executed. From time T**13** and later, until the next gyro signal is loaded, the process in connection to the first communication bus becomes free.

(55) Then, focusing on the process in connection to the second communication bus (the lower part of the present drawing), at time T**21** (=time T**11**), the second sensor **320** detects the position of the object **20**. The second sensor **320** supplies the second position signal indicating the detected position of the object **20** to the second slave port **310** and the second driving unit **330**. The second slave port **310** outputs the second position signal to the first driver **200**. According to this, the first driver **200** obtains the second position signal via the second master port **250**. In this manner, in the period from time T**21** to T**22**, a loading process of data (the detection position of the y axis direction) from the second driver **300** is executed. From time T**22** and later, until time T**23** (=time T**13**) when the writing process of data to the first driver **200** ends, the process in connection to the second communication bus becomes free.

(56) It is noted that the first driver **200**, at any time until time T**23**, may detect the position of the object **20** and make the first position signal indicating the detected position of the object **20** in a state in which it is available. That is, the first sensor **220**, at any time until time T**23**, may detect the position of the object **20**, and supply the first position signal indicating the detected position of the object **20** to the first driving unit **230** and the calculating unit **260**.

(57) At time T**23**, the calculating unit **260** executes the correcting calculation and corrects at least any of the first position control signal, the first position signal, and the second position control signal. The calculating unit **260** corrects at least any of the first position control signal and the first position signal and notifies said effect to the first driving unit **230**. According to this, the first driving unit **230** applies driving force to the object **20** by executing PID control based on at least any of the corrected first position control signal and the first position signal. In addition, the calculating unit **260** corrects the second position control signal and notifies said effect to the second position control unit **240**. According to this, the second position control unit **240** supplies the corrected second position control signal to the second master port **250**.

(58) At time T**24**, the second master port **250** outputs the second position control signal to the second driver **300**. According to this, the second driver **300** obtains the second position control signal via the second slave port **310**. In this manner, in the period from time T**24** to T**25**, a writing process of data (the target position of the y axis direction) to the second driver **300** is executed. According to this, the second driving unit **330** applies driving force to the object **20** by executing PID control based on the second position control signal and the second position signal. From time T**25** and later, until the next gyro signal is loaded, the process in connection to the second communication bus becomes free. For example, in this manner, the camera module **10** according to the present embodiment executes the lens shift type OIS process.

(59) As in Patent document 1, when the first OIS driver and the second OIS driver have a slave

connection with the OIS controller, and the OIS controller centrally controls the two OIS drivers alone, the load on the OIS controller increases. In addition, communication time and calculation time for correction becomes longer, and communication buses between the OIS controller and each OIS driver become pressured. Meanwhile, in the camera module **10** according to the present embodiment, the first driver **200** has a slave connection in relation to the controller **100**, and the second driver **300** has a slave connection in relation to the first driver **200**. The first driver **200** is also for performing a function as a sub-controller. In this way, according to the camera module **10** according to the present embodiment, it is possible to mitigate the processing load in the controller **100**, such as making a correcting calculation in the controller **100** not required. In addition, according to the camera module **10** according to the present embodiment, in addition to making communication for a correcting calculation in the first communication bus not required, it is possible to reduce the communication amount for a correcting calculation also in the second communication bus. Accordingly, according to the camera module **10** according to the present embodiment, since it is possible to increase the communication amount that can be handled in the first communication bus and the second communication bus, it is possible to further aim for high performance, and it allows for extensions such as increasing the number of devices that can be handled by the controller **100** or the like.

(60) FIG. **6** shows an example of a block diagram of the camera module **10** according to a second embodiment. The camera module **10** according to the present embodiment executes a plurality of lens shift type OIS processes. In the present drawing, the same signs are designated in relation to members having the same functions and configurations as those in FIG. **1**, and the description thereof will be omitted except for the following differences. Herein, for convenience of explanation, in FIG. **1**, the “object **20**” is referred to as a “first object **20_1**” and the “lens **30**” is referred to as a “first lens **30_1**”. The camera module **10** according to the present embodiment further includes a second object **20_2**, a third coil **50_3** and a fourth coil **504**, a third driver **400**, and a fourth driver **500**. In the present embodiment, the first driver **200** and the second driver **300** configure a first module, and the third driver **400** and the fourth driver **500** configure a second module.

(61) The second object **20_2** may be similar to the first object **20_1**. The second object **20_2** is provided with a second lens **30_2**, a third magnet **40_3**, and a fourth magnet **40_4**. The second lens **30_2** may be similar to the first lens **30_1**. The third magnet **40_3** and the fourth magnet **40_4** may respectively be similar to the first magnet **40_1** and the second magnet **40_2**.

(62) The third coil **50_3** and the fourth coil **50_4** may respectively be similar to the first coil **50_1** and the second coil **50_2**.

(63) In the present embodiment, the controller **100**, in addition to the first driver **200**, also has a master connection in relation to the third driver **400**, and outputs a generated third position control signal to the third driver **400**.

(64) The third driver **400** may be similar to the first driver **200**. That is, the third driver **400** has a slave connection in relation to the controller **100**, and supplies a driving current to the third coil **50_3** based on the third position control signal output from the controller **100**. In addition, the third driver **400** is also for performing a function as a sub-controller. That is, the third driver **400** has a master connection in relation to the fourth driver **500**, and outputs a generated fourth position control signal to the fourth driver **500**.

(65) The fourth driver **500** may be similar to the second driver **300**. That is, the fourth driver **500** has a slave connection in relation to the third driver **400**, and supplies a driving current to the fourth coil **50_4** based on the fourth position control signal output from the third driver **400**.

(66) In the present embodiment, the first driver **200** is also for performing a function as a sub-controller of the first module, and the third driver **400** is also for performing a function as a sub-controller of the second module. In this way, the camera module **10** according to the present embodiment executes a plurality of lens shift type OIS processes.

(67) FIG. **7** shows an example of a timing diagram of the camera module **10** according to the second embodiment. The upper part of the present drawing shows a process in connection to a first communication bus in between the controller **100** and the first driver **200** and the third driver **400**. The middle part of the present drawing shows a process in connection to a second communication bus in between the first driver **200** and the second driver **300**. The lower part of the present drawing shows a process in connection to a third communication bus in between the third driver **400** and the fourth driver **500**. In addition, in the present drawing, the horizontal axis indicates time.
(68) First, focusing on the process in connection to the first communication bus (the upper part of the present drawing), in the period from time T**11** to T**12**, an OIS (OIS **1**) calculation of the first module is executed. In the period from time T**12** to T**13**, an OIS (OIS **2**) calculation of the second module is executed. In the period from time T**13** to T**14**, a writing process of data (the target position of the x axis direction and the y axis direction regarding the first module) to the first driver **200** is executed. In the period from time T**14** to T**15**, a writing process of data (the target position of the x axis direction and the y axis direction regarding the second module) to the third driver **400** is executed. From time T**15** and later, until the next gyro signal is loaded, the process in connection to the first communication bus becomes free.
(69) The process in connection to the second communication bus (the middle part of the present drawing) may be similar to that in the first embodiment (the lower part of FIG. **5**), so its description is omitted herein.
(70) Then, focusing on the process in connection to the third communication bus (the lower part of the present drawing), in the period from time T**31** (=time T**11**) to time T**32** (=time T**23**), the process in connection to the third communication bus becomes free. In the period from time T**32** to T**33**, a loading process of data (the detection position of the y axis direction regarding the second module) from the fourth driver **500** is executed. From time T**33** and later, until time T**34** (=time T**15**) when the writing process of data to the third driver **400** ends, the process in connection to the third communication bus becomes free. It is noted that at any time until time T**34**, the third driver **400** may detect the position of the second object **20_2** and make the third position signal indicating the detected position of the second object **20_2** in a state in which it is available. In the period from time T**34** to T**35**, a correcting calculation of the second module is executed. In the period from time T**35** to T**31**, a writing process of data (the target position of the y axis direction regarding the second module) to the fourth driver **500** is executed. For example, in this manner, the camera module **10** according to the present embodiment executes a plurality of lens shift type OIS processes.
(71) In this manner, in the camera module **10** according to the present embodiment, the first driver **200** and the third driver **400** have a slave connection in relation to the controller **100**. Respectively, the second driver **300** has a slave connection in relation to the first driver **200**, and the fourth driver **500** has a slave connection in relation to the third driver **400**. The first driver **200** is also for performing a function as a sub-controller in the first module, and the third driver **400** is also for performing a function as a sub-controller in the second module. In this way, according to the camera module **10** according to the present embodiment, since it is possible to increase the number of modules that can be controlled by the controller **100**, it is possible to execute a plurality of OIS processes in the cycle of loading the gyro signal.
(72) FIG. **8** shows an example of a block diagram of the camera module **10** according to a third embodiment. The camera module **10** according to the present embodiment, similarly to the camera module **10** according to the second embodiment, executes a plurality of lens shift type OIS processes. In the present drawing, the same signs are designated in relation to members having the same functions and configurations as those in FIG. **6**, and the description thereof will be omitted except for the following differences.
(73) In the present embodiment, the third driver **400** may be similar to the second driver **300** and the fourth driver **500**. That is, the controller **100** may have a master connection only in relation to

the first driver **200**. The third driver **400** may have a slave connection in relation to the first driver **200**, similarly to the second driver **300** and the fourth driver **500**.
(74) In the present embodiment, the first driver **200** is also for performing a function as a common sub-controller of the first module and the second module. In this way, the camera module **10** according to the present embodiment executes a plurality of lens shift type OIS processes.
(75) FIG. **9** shows an example of a timing diagram of the camera module **10** according to the third embodiment. The upper part of the present drawing shows a process in connection to the first communication bus in between the controller **100** and the first driver **200**. The lower part of the present drawing shows a process in connection to a second communication bus in between the first driver **200**, the second driver **300**, the third driver **400**, and the fourth driver **500**. In addition, in the present drawing, the horizontal axis indicates time.
(76) First, focusing on the process in connection to the first communication bus (the upper part of the present drawing), since, except for the point that, in the period from time T**14** to T**15**, a writing process on data (the target position of the x axis direction and the y axis direction regarding the second module) is executed in relation to the third driver **400** instead of being executed in relation to the first driver **200**, it may be similar to that the second embodiment (upper part of FIG. **7**), its description will be omitted herein.
(77) Then, focusing on the process in connection to the second communication bus (the lower part of the present drawing), in the period from time T**21** to T**22**, a loading process of data (the detection position of the y axis direction regarding the first module) from the second driver **300** is executed. In the period from time T**22** to T**23**, a loading process of data (the detection position of the x axis direction and the y axis direction regarding the second module) from the third driver **400** and the fourth driver **500** is executed. It is noted that the first driver **200**, at any time until time T**23**, may detect the position of the first object **20_1** and make the first position signal indicating the detected position of the first object **20_1** in a state in which it is available. In the period from time T**23** to T**24**, a correcting calculation of the first module is executed. In the period from time T**24** to T**25**, a writing process of data (the target position of the y axis direction regarding the first module) to the second driver **300** is executed. From time T**25** and later, until time T**26** (=time T**15**) when the writing process of data regarding the second module to the first driver **200** ends, the process in connection to the second communication bus becomes free. In the period from time T**26** to T**27**, a correcting calculation of the second module is executed. In the period from time T**27** to T**21**, a writing process of data (the target position of the x axis direction and the y axis direction regarding the second module) to the third driver **400** and the fourth driver **500** is executed. For example, in this manner, the camera module **10** according to the present embodiment executes a plurality of lens shift type OIS processes.
(78) In this manner, in the camera module **10** according to the present embodiment, in executing a plurality of OIS processes, the first driver **200** is also for performing a function as a common sub-controller of the first module and the second module. In this way, according to the camera module **10** according to the present embodiment, it is possible to reduce the number of drivers that are also for performing a function as a sub-controller.
(79) It is noted that, in the description, a case where the camera module **10** executes the lens shift type OIS process as an example, but it is not limited to this. The camera module **10** may execute various types of OIS processes.
(80) FIG. **10** shows an example of a block diagram of the camera module **10** according to a fourth embodiment. The camera module **10** according to the present embodiment executes a sensor shift type OIS process. In the sensor shift type OIS process, by moving the object **20** and shifting an image sensor (imaging element), the optical axis is maintained in the center portion of the image to mitigate video distortion due to camera shake. That is, the first position control unit **130** may generate a first position control signal indicating a first target position to which the object **20** provided with the image sensor or the lens **30** is to be moved. In the present drawing, the same

signs are designated in relation to members having the same functions and configurations as those in FIG. **6**, and the description thereof will be omitted except for the following differences. Herein, for convenience of explanation, in FIG. **6**, the "first object **20_1**" is referred to as the "object **20**", and the "first lens **30_1**" is referred to as the "lens **30**". In the present embodiment, the third magnet **40_3** and the fourth magnet **40_4** are provided on the same object **20** as the first magnet **40_1** and the second magnet **40_2**. That is, in the present embodiment, four of the magnets **40** are provided on one of the object **20**.

(81) In the camera module **10** according to the present embodiment, the first driver **200** and the third driver **400** are also for performing functions as sub-controllers, and the first driver **200** to the fourth driver **500** are used to provide driving forces from four directions to the object **20**, thereby executing the sensor shift type OIS process.

(82) FIG. **11** shows an example of a block diagram of the camera module **10** according to a fifth embodiment. The camera module **10** according to the present embodiment, similarly to the camera module **10** according to the fourth embodiment, executes a sensor shift type OIS process. In the present drawing, the same signs are designated in relation to members having the same functions and configurations as those in FIG. **10**, and the description thereof will be omitted except for the following differences.

(83) In the present embodiment, the third driver **400** may be similar to the second driver **300** and the fourth driver **500**. That is, the controller **100** may have a master connection only in relation to the first driver **200**. The third driver **400** may have a slave connection in relation to the first driver **200**, similarly to the second driver **300** and the fourth driver **500**.

(84) In the camera module **10** according to the present embodiment, the first driver **200** is also for performing a function as a common sub-controller, and the first driver **200** to the fourth driver **500** are used to provide driving forces from four directions to the object **20**, thereby executing the sensor shift type OIS process.

(85) FIG. **12** shows an example of a block diagram of the camera module **10** according to a sixth embodiment. The camera module **10** according to the present embodiment, similarly to the camera module **10** according to the fifth embodiment, executes a sensor shift type OIS process. In the present drawing, the same signs are designated in relation to members having the same functions and configurations as those in FIG. **11**, and the description thereof will be omitted except for the following differences.

(86) In the present embodiment, the object **20** is provided with the lens **30**, the first magnet **40_1**, the second magnet **40_2**, and the third magnet **40_3**. The third magnet **403** is provided on the same side as the side in the object **20** on which the first magnet **401** is provided.

(87) In the camera module **10** according to the present embodiment, the first driver **200** is also for performing a function as a common sub-controller, and the first driver **200** to the third driver **400** are used to provide one driving force from a first direction and provide two driving forces from a second direction to the object **20**, thereby executing the sensor shift type OIS process.

(88) In this manner, the camera module **10** may execute the sensor shift type OIS process. Herein, a case where the camera module **10** executes the lens shift type OIS process as an example, but it is not limited to this. The camera module **10** may execute an auto focus (AF)/Zoom process.

(89) FIG. **13** shows an example of a block diagram of the camera module **10** according to a seventh embodiment. The camera module **10** according to the present embodiment executes an AF/Zoom process. In the AF/Zoom process, by moving an object along the optical axis direction, focusing and enlargement/reduction is performed.

(90) In the present embodiment, the camera module **10** includes an object **20′**, a coil **50′**, a controller **100′**, a driver **200′**, and a position detector **300′**.

(91) The object **20′** is a linear motion device whose position changes along the optical axis direction according to an input signal. The object **20′** is provided with a lens **30′** and a magnet **40′**. The magnet **40′** is disposed along the optical axis direction of the lens **30′**.

(92) The coil **50′** are wound along the optical axis direction of the lens **30′** similarly to the magnet **40′**, nearby the magnet **40′**. When a driving current is supplied to such the coil **50′**, since a magnetic force is generated between the coil **50′** and the magnet **40′**, the object **20′** is displaced along the optical axis direction of the lens **30′**. In this way, focusing and enlargement/reduction is possible.
(93) The controller **100′** is a high-order controller for controlling the AF/Zoom process. In the present embodiment, the controller **100′** may be mounted as a part of a function of a host. The controller **100′** includes a position control unit **130′** and a first master port **140′**.
(94) The position control unit **130′** generates a position control signal indicating a target position to which the object **20′** provided with the lens **30′** is to be moved. The position control unit **130′** supplies the generated position control signal to the first master port **140′**.
(95) The first master port **140′** is connected to a slave port in the driver **200′**. The first master port **140′** outputs the position control signal generated by the position control unit **130′** to the driver **200′**.
(96) The driver **200′** is a driver for providing driving force to the object **20′**. In the present embodiment, the driver **200′** may be an AF/Zoom driver. The driver **200′** has a slave connection in relation to the controller **100′**, and supplies a driving current to the coil **50′** based on the position control signal output from the controller **100′**. In addition, the driver **200′** is also for performing a function as a sub-controller. That is, the driver **200′** has a master connection in relation to the position detector **300′**, and obtains the position information and corrects the detection position. The driver **200′** includes a first slave port **210′**, a sensor **220′**, a driving unit **230′**, a second master port **250′**, and a calculating unit **260′**.
(97) The first slave port **210′** is connected to the first master port **140′** in the controller **100′**. The driver **200′** obtains the position control signal from the controller **100′** via the said first slave port **210′**. The obtained position control signal is supplied to the driving unit **230′**.
(98) The sensor **220′** detects the position of the object **20′**. The sensor **220′** supplies a position signal indicating the detected position of the object **20′** to the calculating unit **260′**.
(99) The driving unit **230′** applies driving force to the object **20′** based on the position control signal. In this case, the driving unit **230′** applies the driving force to the object **20′** based on the position information indicating the position of the object **20′** detected by the position detector **300′** and the position control signal.
(100) The position detector **300′** has a slave connection with the second master port **250′**. The driver **200′** obtains the position information indicating the position of the object **20′** detected by the position detector **300′** via the said second master port **250′**. The obtained position information is supplied to the calculating unit **260′**.
(101) The calculating unit **260′** corrects the detection position of the object **20′** by using the position signal and the position information. In this case, for example, as in Japanese utility model application no. 3189365, the calculating unit **260′** may correct the detection position based on a result of dividing the sum of the position signal and the position information by the difference between the position signal and the position information. In addition, for example, as in Japanese patent no. 4612281, the calculating unit **260′** may correct the detection position based on a result of dividing the difference of the position signal and the position information by the sum of the position signal and the position information. In addition, the calculating unit **260′** may correct the detection position by selectively adopting the position signal in a first interval, and selectively adopting the position information in a second interval. For example, in this manner, the calculating unit **260′** supplies information indicating the corrected detection position to the driving unit **230′**.
(102) According to this, the driving unit **230′** may generate a control signal for moving the detection position to the target position indicated by the position control signal. The driving unit **230′** may supply a driving current according to the control signal to the coil **50′**. In this manner, the driving unit **230′** may provide driving force to the object **20′** based on the position signal and position information indicating the position of the object **20′** detected by the sensor **220′**, and the

position control signal.

(103) The position detector **300′** is an extension device for detecting the position of the object **20′**. The position detector **300′** has a slave connection in relation to the driver **200′**, and outputs the position information indicating the detected position of the object **20′** to the driver **200′**. The position detector **300′** includes a second slave port **310′** and an extension sensor **320′**.

(104) The second slave port **310′** is connected to the second master port **250′** in the driver **200′**. The second slave port **310′** outputs the position information indicating the position of the object **20′** detected by the extension sensor **320′** to the driver **200′**.

(105) The extension sensor **320′** detects the position of the object **20′**. The extension sensor **320′** supplies the position information indicating the detected position of the object **20′** to the second slave port **310′**.

(106) FIG. **14** shows an example of a timing diagram of the camera module **10** according to the seventh embodiment. The upper part of the present drawing shows a process in connection to a first communication bus in between the controller **100′** and the driver **200′**. The lower part of the present drawing shows a process in connection to a second communication bus in between the driver **200′** and the position detector **300′**. In addition, in the present drawing, the horizontal axis indicates time.

(107) First, focusing on the process in connection to the first communication bus (the upper part of the present drawing), in the period from time T**11** to T**12**, a writing process of data (the target position) to the driver **200′** is executed. From time T**12** and later, until the writing process of data to the driver **200′** is started, the process in connection to the first communication bus becomes free.

(108) Then, focusing on the process in connection to the second communication bus (the lower part of the present drawing), in the period from time T**21** (=time T**11**) to T**22**, a loading process of data (the position information) from the position detector **300′** is executed. It is noted that the driver **200′**, at any time until time T**22**, may detect the position of the object **20′** and make the position signal indicating the detected position of the object **20′** in a state in which it is available. In the period from time T**22** to T**23**, a lens position calculation is executed. That is, the calculating unit **260′** corrects the detection position of the object **20′** by using the position signal and the position information. The calculating unit **260′** supplies information indicating the corrected detection position to the driving unit **230′**. According to this, the driving unit **230′** may generate a control signal for moving the detection position to the target position indicated by the position control signal. The driving unit **230′** may supply a driving current according to the control signal to the coil **50′**. From time T**23** and later, until a next writing process to the driver **200′** is started, the process from time T**21** to time T**23** may be executed repeatedly. For example, in this manner, the camera module **10** according to the present embodiment executes the AF/Zoom process.

(109) In this manner, in the camera module **10** according to the present embodiment, the driver **200′** has a slave connection in relation to the controller **100′**, and the position detector **300′** has a slave connection in relation to the driver **200′**. The driver **200′** is also for performing a function as a sub-controller. In this way, according to the camera module **10** according to the present embodiment, it is possible to mitigate the processing load in the controller **100′**, such as that the lens position calculation in the controller **100′** is not required. In addition, according to the camera module **10** according to the present embodiment, communication for the lens position calculation in the first communication bus is not required. Accordingly, according to the camera module **10** according to the present embodiment, since it is possible to increase the communication amount that can be handled in the communication buses, it is possible to further aim for high performance, and it allows for extensions such as increasing the number of devices that can be handled by the controller **100′** or the like.

(110) FIG. **15** shows an example of a block diagram of the camera module **10** according to an eighth embodiment. The camera module **10** according to the present embodiment, similarly to the camera module **10** according to the seventh embodiment, executes an AF/Zoom process. In the

present drawing, the same signs are designated in relation to members having the same functions and configurations as those in FIG. **13**, and the description thereof will be omitted except for the following differences.

(111) In the present embodiment, the position detector **300′** is configured by a position detecting element group made up of a plurality of position detecting elements. The present drawing shows an example of when the position detector **300′** is configured by a position detecting element group made up of a first position detecting element **300′_1**, a second position detecting element **300′**_2, . . . , and a Nth position detecting element **300′**_N.

(112) The first position detecting element **300′_1**, the second position detecting element **300′_2**, . . . , and the Nth position detecting element **300′**_N each include the extension sensor **320′** for detecting the position of the object **20′**, and the second slave port **310′** connected to the second master port **250′** in the driver **200′**.

(113) FIG. **16** shows an example of a timing diagram of the camera module **10** according to the eighth embodiment. The upper part of the present drawing shows a process in connection to a first communication bus in between the controller **100′** and the driver **200′**.

(114) The lower part of the present drawing shows a process in connection to a second communication bus in between the driver **200′** and the first position detecting element **300′_1**, the second position detecting element **300′_2**, . . . , and the Nth position detecting element **300′**_N. In addition, in the present drawing, the horizontal axis indicates time.

(115) The process in connection to the first communication bus (the upper part of the present drawing) may be similar to that in the seventh embodiment (the upper part of FIG. **14**), so its description is omitted herein.

(116) Then, focusing on the process in connection to the second communication bus (the lower part of the present drawing), in the period from time T**21** (=time T**11**) to T**22**, a loading process of data (the position information) from the first position detecting element **300′_1** is executed. Similarly, in the period from time T**22** to T**23**, a loading process of data (the position information) from the second position detecting element **300′_2** is executed.

(117) Similarly, in the period from time T**2**N to T**2**N+a, a loading process of data (the position information) from the Nth position detecting element **300′**_N is executed. In the period from time T**2**N+1 to T**2**Z, a lens position calculation is executed. From time T**2**Z and later, until a next writing process to the driver **200′** is started, the process from time T**21** to time T**2**Z may be executed repeatedly. For example, in this manner, the camera module **10** according to the present embodiment executes the AF/Zoom process.

(118) In general, when controlling the object **20′** by an AF/Zoom process over a long distance, a case is possible where the detectable distance is insufficient with just the sensor mounted to the AF/Zoom driver and an extension of the sensor is required. In the camera module **10** according to the present embodiment, the driver **200′** has a slave connection to the controller **100′**, and the plurality of the position detecting elements **300′_1** to **300′**_N each has a slave connection in relation to the driver **200′**. The driver **200′** is also for performing a function as a sub-controller. In this way, according to the camera module **10** according to the present embodiment, since it is possible to extend the detectable distance, the object **20′** can be controlled over a long distance. In addition, since communication for the lens position calculation in the first communication bus is not required even in this case, it allows for extensions such as increasing the number of devices that can be handled by the controller **100′** or the like. That is, according to the camera module **10** according to the present embodiment, it is also possible to connect a plurality of systems made up of the object **20′**, the coil **50′**, the driver **200′**, and the position detector **300′** to the controller **100′**, and execute a distributed process of a plurality of cameras.

(119) FIG. **17** shows an example of a block diagram of the camera module **10** according to a ninth embodiment. The camera module **10** according to the present embodiment executes an AF/Zoom tracking process. In the present drawing, the same signs are designated in relation to members

having the same functions and configurations as those in FIG. **13**, and the description thereof will be omitted except for the following differences. Herein, for convenience of explanation, in FIG. **15**, the “object **20′**” is referred to as a “first object **20′_1**” and the “coil **50′**” is referred to as a “first coil **50′_1**”. The camera module **10** according to the present embodiment further includes a second object **20′_2** and a second coil **50′_2**.

(120) The second object **20′_2** may be similar to the first object **20′_1**. The second coil **50′_2** may be similar to the first coil **50′_1**.

(121) A first driver **200″** is a driver for driving the first object **20′_1** provided with a first lens **30′_1** along an optical axis direction of the first lens **30′_1**. In the present embodiment, the first driver **200″** may be one of a Zoom driver or an AF driver.

(122) A second driver **300″** is a driver for driving the second object **20′_2** provided with a second lens **30′_2** in an optical axis direction of the second lens **30′_2**. In the present embodiment, the second driver **300″** may be the other one of the Zoom driver or the AF driver.

(123) In such a case, a calculating unit **260″** including the first driver **200″** may correct at least any of a first position control signal, a first position signal, and a second position control signal in such a way so that the first object **20′_1** and the second object **20′_2** interlock.

(124) FIG. **18** shows a first example of a timing diagram of the camera module **10** according to the ninth embodiment. The present drawing shows a case where the first driver **200″** is a Zoom driver and the second driver **300″** is an AF driver. The upper part of the present drawing shows a process in connection to a first communication bus in between the controller **100′** and the first driver **200″**. The lower part of the present drawing shows a process in connection to a second communication bus in between the first driver **200″** and the second driver **300″**. In addition, in the present drawing, the horizontal axis indicates time.

(125) First, focusing on the process in connection to the first communication bus (the upper part of the present drawing), in the period from time T**11** to T**12**, a writing process of data (the target position) to the first driver **200″**, that is, the Zoom driver, is executed. From time T**12** and later, until a next writing process of data to the Zoom driver is started, the process in connection to the first communication bus becomes free.

(126) Then, focusing on the process in connection to the second communication bus (the lower part of the present drawing), in the period from time T**21** (=time T**11**) to T**22**, a lens position tracking calculation is executed. That is, the calculating unit **260″** may calculate an AF lens position along a tracking curve based on a detection position by a sensor on the Zoom driver side. Such a calculation is known, so its description is omitted herein. In the period from time T**22** to T**23**, a writing process of data (the lens position) to the second driver **300″**, that is, the AF driver is executed. From time T**23** and later, until a next writing process to the Zoom driver is started, the process in the period from time T**21** to T**23** is executed repeatedly. For example, in this manner, the camera module **10** according to the present embodiment executes the AF/Zoom tracking process with the Zoom driver as a master.

(127) FIG. **19** shows a second example of a timing diagram of the camera module **10** according to the ninth embodiment. The present drawing shows a case where the first driver **200″** is an AF driver and the second driver **300″** is a Zoom driver. The upper part of the present drawing shows a process in connection to a first communication bus in between the controller **100′** and the first driver **200″**. The lower part of the present drawing shows a process in connection to a second communication bus in between the first driver **200″** and the second driver **300″**. In addition, in the present drawing, the horizontal axis indicates time.

(128) First, focusing on the process in connection to the first communication bus (the upper part of the present drawing), in the period from time T**11** to T**12**, a writing process of data to the second driver **300″**, that is, the Zoom driver, is executed. In this case, the first driver **200″** bypasses the writing process from the controller **100′** via the first communication bus to the second driver **300″** via the second communication bus. From time T**12** and later, until a next writing process of data to

the Zoom driver is started, the process in connection to the first communication bus becomes free.
(129) Then, focusing on the process in connection to the second communication bus (the lower part of the present drawing), in the period from time T**21** (=time T**11**) to T**22** (=time T**12**), a writing process of data to the second driver **300**″, that is, the Zoom driver is executed. In the period from time T**22** to T**23**, a loading process of data from the second driver **300**″ is executed. In the period from time T**23** to T**24**, a lens position tracking calculation is executed. From time T**24** and later, until a next writing process to the Zoom driver is started, the process in the period from time T**21** to T**24** is executed repeatedly. For example, in this manner, the camera module **10** according to the present embodiment executes the AF/Zoom tracking process with the AF driver as a master.
(130) In general, a Zoom and AF lens require to be tracked and controlled. In the camera module **10** according to the present embodiment, the first driver **200**″ that is one of the Zoom driver or the AF driver has a slave connection to the controller **100**′, and the second driver **300**″ that is the other one of the Zoom driver or the AF driver has a slave connection in relation to the first driver **200**″. The first driver **200**″ is also for performing a function as a sub-controller. In this way, according to the camera module **10** according to the present embodiment, it is possible to mitigate the processing load in the controller **100**′, such as that a lens position tracking calculation in the controller **100**′ is not required. In addition, according to the camera module **10** according to the present embodiment, communication for the lens position tracking calculation in the first communication bus is not required. Accordingly, according to the camera module **10** according to the present embodiment, since it is possible to increase the communication amount that can be handled in the communication buses, it is possible to further aim for high performance, and it allows for extensions such as increasing the number of devices that can be handled by the controller **100**′ or the like.
(131) FIG. **20** shows an example of a block diagram of the camera module **10** according to a tenth embodiment. The camera module **10** according to the present embodiment executes a drive extending and tilt correcting process. In the present drawing, the same signs are designated in relation to members having the same functions and configurations as those in FIG. **13**, and the description thereof will be omitted except for the following differences.
(132) Herein, for convenience of explanation, in FIG. **13**, the “magnet **40**′” is referred to as a “first magnet **40′_1**” and the “coil **50**′” is referred to as the “first coil **50′_1**”. The camera module **10** according to the present embodiment further includes a second magnet **40′_2** and the second coil **50′_2**. Herein, the second magnet **40′_2** may be provided on the object **20**′ in such a way so that it faces the first magnet **40′_1**.
(133) A first driver **200**‴ is a driver for driving the object **20** provided with the lens **30** in an optical axis direction of the lens **30**. In the present embodiment, the first driver **200**‴ may be an AF driver.
(134) A second driver **300**‴ is a driver for extending the drive capacity of the first driver **200**‴. In addition, the second driver **300**‴ may have a position detecting function and be a driver for adjusting tilt of the object **20**′. In the present embodiment, the second driver **300**‴ may be an extension driver including the position detecting function.
(135) In such a case, a calculating unit **260**‴ including the first driver **200**‴ may correct the tilt in relation to an optical axis of the lens **30** in the object **20** based on position information.
(136) FIG. **21** shows an example of a timing diagram of the camera module **10** according to the tenth embodiment. The upper part of the present drawing shows a process in connection to a first communication bus in between the controller **100**′ and the first driver **200**‴. The lower part of the present drawing shows a process in connection to a second communication bus in between the first driver **200**‴ and the second driver **300**‴. In addition, in the present drawing, the horizontal axis indicates time.
(137) First, focusing on the process in connection to the first communication bus (the upper part of the present drawing), in the period from time T**11** to T**12**, a writing process of data to the first driver **200**‴, that is, the AF driver, is executed. From time T**12** and later, until a next writing

process of data to the AF driver is started, the process in connection to the first communication bus becomes free.

(138) Then, focusing on the process in connection to the second communication bus (the lower part of the present drawing), in the period from time T**21** (=time T**11**) to T**22**, a loading process of data from the second driver **300**‴, that is, the extension driver is executed. In the period from time T**22** to T**23**, the drive extending and tilt correcting calculation is executed. That is, the calculating unit **260**‴ may calculate a drive amount and a tilt amount by the extension driver based on the position information. In the period from time T**23** to T**24**, a writing process of data to the second driver **300**′″, that is, the extension driver is executed. From time T**24** and later, until a next writing process to the AF driver is started, the process in the period from time T**21** to T**24** is executed repeatedly. For example, in this manner, the camera module **10** according to the present embodiment executes a drive extending and tilt correcting process.

(139) In general, when controlling the object **20**′ by an AF/Zoom process over a long distance, a case is possible where the torque is not sufficient with just one driver and an extension of the driver is required. In addition, there may be a case where tilt correction is required. In the camera module **10** according to the present embodiment, the first driver **200**‴ that is the AF driver has a slave connection to the controller **100**′, and the second driver **300**‴ that is the extension driver has a slave connection in relation to the first driver **200**‴. The first driver **200**‴ is also for performing a function as a sub-controller. In this way, according to the camera module **10** according to the present embodiment, it is possible to mitigate the processing load in the controller **100**′, such as that the drive extending and tilt correcting calculation in the controller **100**′ is not required. In addition, according to the camera module **10** according to the present embodiment, communication for the drive extending and tilt correcting calculation in the first communication bus is not required. Accordingly, according to the camera module **10** according to the present embodiment, since it is possible to increase the communication amount that can be handled in the communication buses, it is possible to further aim for high performance, and it allows for extensions such as increasing the number of devices that can be handled by the controller **100**′ or the like.

(140) While the present invention has been described by using embodiments of the present invention, the technical scope of the present invention is not limited to the scope according to the above described embodiments. It is apparent to persons skilled in the art that various alterations or improvements can be added to the above-described embodiments. It is also apparent from the description of the scope of claims that the embodiments added with such alterations or improvements can be included in the technical scope of the present invention.

(141) The actions, procedures, steps, and stages of each process performed by an apparatus, system, program, and method shown in the scope of claims, specification, or drawings can be executed in any order as long as the order is not indicated by “prior to,” “before,” or the like, and in addition, as long as the output from a previous process is not used in a later process. Even if the action flow is described by using phrases such as “first” or “then” in the scope of claims, specification, or drawings, it does not necessarily mean that the process must be performed in this order.

EXPLANATION OF REFERENCES

(142) **10** camera module **20** object **30** lens **40** magnets **50** coils **100** controller **110** high-order slave port **120** high-order master port **130** first position control unit **140** first master port **200** first driver **210** first slave port **220** first sensor **230** first driving unit **240** second position control unit **250** second master port **260** calculating unit **300** second driver (**300**′ position detector) **310** second slave port **320** second sensor **330** second driving unit **400** third driver **500** fourth driver

Claims

1. A camera module, comprising: a controller that generates a first position control signal indicating a first target position to which an object provided with an image sensor or a lens is to be moved, and a first master port configured to output the first position control signal; a first driver, including a first slave port connected to the first master port, configured to provide driving force to the object based on the first position control signal and to generate a second position control signal indicating a second target position to which the object is to be moved, and a second master port configured to output the second position control signal; and a second driver controlled by the first driver, including a second slave port connected to the second master port, configured to provide driving force to the object based on the second position control signal; wherein the first driver further includes a first sensor configured to detect a position of the object, and the first driver is configured to provide driving force to the object based on a first position signal indicating a position of the object detected by the first sensor, and the first position control signal; the second driver further includes a second sensor configured to detect a position of the object, and the second driver is configured to apply driving force to the object based on a second position signal indicating a position of the object detected by the second sensor, and the second position control signal; and the first driver further is configured to correct, after the controller outputs the first position control signal and before the controller outputs a next one of the first position control signal, at least any of the first position control signal and the first position signal using the second position signal obtained directly by the second driver via the second master port, without use of the controller and the first slave port, wherein the driving force applied to the object is based on such correction to any of the first position signal and the first position control signal.
2. The camera module according to claim 1, wherein the first driver is configured to correct at least any of the first position control signal, the first position signal, and the second position control signal in such a way so as to reduce mutual interference by drive of the object by the first driver and drive of the object by the second driver.
3. The camera module according to claim 1, wherein when the first driver is configured to drive a first object provided with a first lens, and the second driver is configured to drive a second object provided with a second lens, the first driver is configured to correct at least any of the first position control signal, the first position signal, and the second position control signal in such a way so that the first object and the second object interlock.
4. The camera module according to claim 1, wherein communication between master and slave is serial communication.
5. The camera module according to claim 1, wherein the camera module is capable of executing at least any of optical image stabilization, auto focus, and zoom processes.
6. A driver, wherein the driver is connected to a controller that is configured to generate a first position control signal indicating a first target position to which an object provided with an image sensor or a lens is to be moved, and having a first master port configured to output the first position control signal, the driver comprises: a first slave port connected to the first master port; a second master port configured to output a second position control signal to another driver; and a first sensor that detects a position of the object; wherein the driver is configured to provide driving force to the object based on the first position control signal; generate the second position control signal indicating a second target position to which the object is to be moved; to provide driving force to the object based on a first position signal indicating a position of the object detected by the first sensor, and the first position control signal, and correct, after the controller outputs the first position control signal and before the controller outputs a next one of the first position control signal, at least any of the first position control signal and the first position signal at least based on a using a second position signal obtained directly by the another driver via the second master port, without use of the controller and the first slave port, wherein the second position signal is different from the first position signal, wherein the driving force applied to the object is based on such correction to

any of the first position signal and the first position control signal.

7. A position control system, comprising: a controller configured to generate a first position control signal indicating a first target position to which an object provided with an image sensor or a lens is to be moved, and a first master port configured to output the first position control signal; a first driver including a first slave port connected to the first master port, configured to provide driving force to the object based on the first position control signal and to generate a second position control signal indicating a second target position to which the object is to be moved, and a second master port configured to output the second position control signal; and a second driver including a second slave port connected to the second master port, configured to provide driving force to the object based on the second position control signal; wherein the first driver further includes a first sensor configured to detect a position of the object, and the first driver is configured to provide driving force to the object based on a first position signal indicating a position of the object detected by the first sensor, and the first position control signal; the second driver further includes a second sensor configured to detect a position of the object, and the second driver is configured to apply driving force to the object based on a second position signal indicating a position of the object detected by the second sensor, and the second position control signal; and the first driver is configured to correct, after the controller outputs the first position control signal and before the controller outputs a next one of the first position control signal, at least any of the first position control signal and the first position signal using the second position signal obtained directly by the second driver via the second master port, without use of the controller and the first slave port, wherein the driving force applied to the object is based on such correction to any of the first position signal and the first position control signal.