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(71) Applicant: **SZ DJI TECHNOLOGY CO., LTD.** [CN/CN]; 6F, HKUST SZ IER Bldg., No.9 Yuexing 1st Rd. Hi-Tech Park (South), Nanshan District, Shenzhen, Guangdong 518057 (CN).

(72) Inventors: **FENG, Jiangang**; 6F, HKUST SZ IER Bldg., No.9 Yuexing 1st Rd. Hi-Tech Park (South), Nanshan District, Shenzhen, Guangdong 518057 (CN). **TANG, Yin**; 6F, HKUST SZ IER Bldg., No.9 Yuexing 1st Rd. Hi-Tech Park (South), Nanshan District, Shenzhen, Guangdong 518057 (CN).

(74) Agents: **SHENZHEN SCIENBIZIP INTELLECTUAL PROPERTY AGENCY CO., LTD.** et al.; 9F, Rongqun Building, No.83 Longguan East Rd., Longhua New Dist., Shenzhen, Guangdong 518109 (CN).

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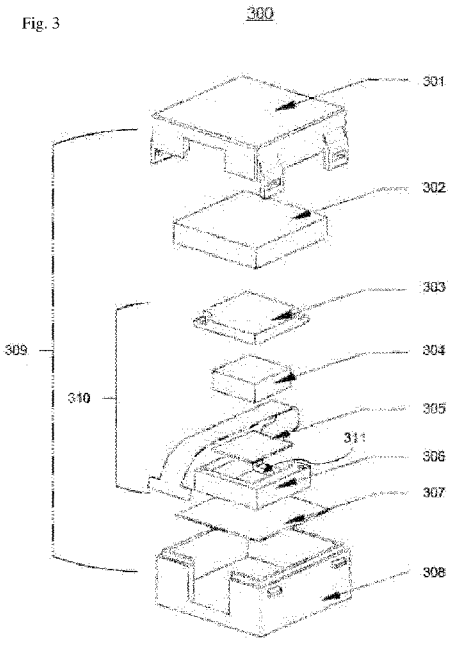
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(54) Title: SYSTEM AND METHOD FOR PROVIDING A SIMPLE AND RELIABLE INERTIA MEASUREMENT UNIT (IMU)

Fig. 3



(57) Abstract: A system and method is provided that can support a measurement module (300) on a movable object. The measurement module (300) includes a first circuit board (305) with one or more sensors. Additionally, the measurement module (300) includes a weight block assembly (310), wherein the weight block assembly (310) is configured to have a mass that keeps an inherent frequency of the measurement module (300) away from an operation frequency of the movable object. Furthermore, the first circuit board (305) can be disposed in an inner chamber (311) within the weight block assembly (310).

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SYSTEM AND METHOD FOR PROVIDING A SIMPLE AND RELIABLE INERTIA MEASUREMENT UNIT (IMU)

BACKGROUND

[0001] Unmanned movable objects such as the unmanned vehicles (e.g. the unmanned aircrafts) can be used for performing various surveillance, reconnaissance, and exploration tasks. An unmanned vehicle may include various sensing devices for determining the present control status and/or states. Thus, the unmanned vehicle can navigate autonomously or semi-autonomously. This is the general area that embodiments of the invention are intended to address.

[0002] SUMMARY

[0003] Described herein are systems and methods that can provide a measurement module on a movable object. The measurement module includes a first circuit board with one or more sensors. Additionally, the measurement module includes a weight block assembly, wherein the weight block assembly is configured to have a mass that keeps an inherent frequency of the measurement module away from an operation frequency of the movable object. Furthermore, said first circuit board can be disposed in an inner chamber within the weight block assembly.

BRIEF DESCRIPTION OF THE DRAWING

[0004] Figure 1 s an exemplary illustration of a vibration model for an unmanned aircraft, in accordance with various embodiments of the present invention.

[0005] Figure 2 is an exemplary illustration of an exploded view for an inertia measurement unit (IMU) with vibration damping, in accordance with various embodiments of the present invention.

[0006] Figure 3 is an exemplary illustration of an exploded view for a simple and reliable inertia measurement unit (IMU), in accordance with various embodiments of the present invention.

[0007] Figure 4 is an exemplary illustration of a partially assembled inertia measurement unit (IMU), in accordance with various embodiments of the present invention.

[0008] Figure 5 is an exemplary illustration of an assembled inertia measurement unit (IMU), in accordance with various embodiments of the present invention.

[0009] Figure 6 is an exemplary illustration of an alternative inertia measurement unit (IMU), in accordance with various embodiments of the present invention.

[0010] Figure 7 shows a flowchart of providing a measurement module on a movable object, in accordance with various embodiments of the present invention.

DETAILED DESCRIPTION

[0011] The invention is illustrated, by way of example and not by way of limitation, in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to "an" or "one" or "some" embodiment(s) in this disclosure are not necessarily to the same embodiment, and such references mean at least one.

[0012] The description of the invention as following uses an unmanned aircraft as example for a movable object. It will be apparent to those skilled in the art that other types of movable objects can be used without limitation.

[0013] A Vibration Model on an Unmanned Aircraft

[0014] In accordance with various embodiments of the present invention, a movable object, such as an unmanned aircraft, an unmanned vehicle, a hand held device, or a robot, can take advantage of a measurement module (or device) for obtaining various types of information that are necessary for controlling the movable object.

[0015] Figure 1 is an exemplary illustration of a vibration model for an unmanned aircraft, in accordance with various embodiments of the present invention. As shown in Figure 1, an unmanned aircraft 100 can use a measurement module, such as an inertia measurement unit (IMU) 101, for determining a spatial disposition (and other fly status parameters) for the unmanned aircraft 100.

[0016] The IMU 101 can include various types of inertia sensors, such as one or more integrated motion sensors and/or one or more integrated orientation sensors. For example, a motion sensor can include a velocity measurement instrument and/or an acceleration measurement instrument (e.g. an accelerometer), and an orientation sensor can include a gyroscope and a gravity gradient sensor (e.g. a gradiometer).

[0017] In accordance with various embodiments of the present invention, the IMU 101 can be placed on different suitable portions of a movable object, such as above, underneath, on the side(s) of, or within the body 110 of the movable object. The IMU 101 may be mechanically coupled to the movable object. Optionally, the IMU 101 can be physically integrated into the movable object.

[0018] As shown in Figure 1, the IMU 101 may be placed on a body 110 of the unmanned aircraft 100, e.g. with a main circuit board 102. The main circuit board 102 can include a control module, which contains various logics for controlling the flight status of the unmanned aircraft 100. The IMU 101 can be electronically coupled with the control module on the unmanned aircraft 100. Then, the IMU 101 can measure the spatial disposition and/or motion of the unmanned aircraft 100.

[0019] Additionally, different vibration sources may be presented on a movable object. The vibration may severely deteriorate the precision and stability of the measurement performed by the IMU 101. Thus, the vibration can be detrimental to the control of the

movable object, since the measurement result of the IMU 101 is important for determining various control parameters.

[0020] As shown in Figure 1, an unmanned aircraft 100 may have one or more motors, each of which can be a vibration source. The vibration 115 may propagate from the motors 111-114, along the body of the unmanned aircraft 100, to the IMU 101.

[0021] In accordance with various embodiments of the present invention, a measurement module, such as the IMU 101, can provide vibration damping for improving measurement stability. For example, the IMU 101 can be coupled to a support base carried by the unmanned aircraft 100 via various damping elements. The amount of damping provided by the damping elements may be optimized based on the types of the inertia sensor in the IMU 101.

[0022] Figure 2 is an exemplary illustration of an exploded view for an inertia measurement unit (IMU) with vibration damping, in accordance with various embodiments of the present invention. As shown in Figure 2, a housing assembly 211 in an IMU 200 includes a first housing member 201 and a second housing member 210, which can be be mated and locked together.

[0023] The IMU 200 further includes a circuit board 205, on which various types of sensors that are sensitive to vibration (such as an inertia sensor) can be disposed. In order to prevent the vibration from deteriorating the performance of such sensors, the circuit board 205 can be made using flexible materials. Alternatively, these sensors, which are sensitive to vibration, can be integrated into the circuit board 205.

[0024] In accordance with various embodiments of the present invention, the IMU 200 can use a weight block 206 for decreasing the inherent frequency of the IMU 200. The inherent frequency of the IMU 200 can be defined using the following equation,

[0025] $$f_n = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

,

[0026] where K represents the elastic coefficient and M represents the mass. Thus, the weight block 206 can be configured to have a mass that can keep the inherent frequency of the IMU 200 away from the operation frequency of an unmanned aircraft, e.g. 50~200 Hz.

[0027] As shown in Figure 2, the circuit board 205 can be placed on a surface of the weight block 206 (e.g. being fixed on the top surface of the weight block 206). Alternatively, the circuit board 205 may be buried in a recessed area on a surface of the weight block 206, e.g. using black glues.

[0028] Additionally, the weight block 206, which provides support for the circuit board 205, can be placed in the housing assembly 211 with vibration reducing films 204 and 207 and foams 203 and 208, which can further reduce the vibration.

[0029] In accordance with various embodiments of the present invention, adhesive materials (e.g. a double-sided tape 209) can be used to fix the weight block 206, the vibration reducing films 204 and 207 and the foams 203 and 208 in the housing assembly 211.

[0030] Additionally, in order to assemble the IMU 200 with satisfactory precision, various tools, such as jig tools, may be used for handling the various components 203-208 appropriately in the housing assembly 211. Also, a positioning device, e.g. a positioning film 202, can be used for precisely placing the different components 203-208 in the housing assembly 200, e.g. on an inner surface of the housing assembly 211.

[0031] A Simple and Reliable Inertia Measurement Unit (IMU)

[0032] Figure 3 is an exemplary illustration of an exploded view for a simple and reliable inertia measurement unit (IMU), in accordance with various embodiments of the present invention. As shown in Figure 3, a housing assembly 309 in an IMU 300 includes a first housing member 301 and a second housing member 308 that can be mated and locked together.

[0033] In accordance with various embodiments of the present invention, the IMU 300 can include a weight block assembly 310. The weight block assembly 310 can be configured to have a mass that can keep the inherent frequency of the IMU 300 away from the operation frequency of the unmanned aircraft (e.g. 50~200 Hz).

[0034] The IMU 300 further includes a circuit board 305, on which different types of sensors sensitive to vibration (such as an inertia sensor) can be disposed. In order to prevent the vibration from deteriorating the performance of such sensors, the circuit board 305 may be made using flexible materials. Alternatively, these sensors, which are sensitive to vibration, can be physically integrated into the circuit board 305.

[0035] As shown in Figure 3, the weight block assembly 310 may include a first weight block 303 and a second weight block 306, which can be tightly coupled to form a weight block assembly 310 with an inner chamber 311. Furthermore, the circuit board 305, which includes an inertia sensor, can be disposed in the inner chamber 311. In other words, the weight block assembly 310 is configured to have an inner chamber that is adapted to contain the circuit board 305 with one or more sensors that support the IMU 300.

[0036] In accordance with various embodiments of the present invention, different coupling mechanisms can be used to tightly couple the first weight block 303 and the second weight block 307 together (i.e., to form the weight block assembly 310). Suitable coupling mechanisms can be based on adhesives, bonding, welding, and/or fasteners (e.g. screws, nails, pins, etc.). Also, the weight block assembly 310 can be fixed in the housing assembly 300 using foams 302 and/or adhesive materials 307.

[0037] Additionally, a thermal interface material 304, which is compressible, can be used to fill in the gap in the inner chamber 311. The thermal interface material 304 can

conduct heat away from the circuit board 305 and prevents the circuit board 305 from moving inside the inner chamber 311 within the weight block assembly 310. For example, the thermal interface material 304 may be based on silica gel, thermal gel, epoxy, phase change materials, polyimide, graphite, aluminum tapes, and/or silicone-coated fabrics.

[0038] In accordance with various embodiments of the present invention, the assembly process for the IMU 300 is straight forward and the size of the IMU 300 can be reduced, since the structure of the IMU 300 is simple. For example, the foams 302 can be preinstalled in a housing member 301 or 308. Furthermore, there is no need of using special tools to handle and position the various components 302-307 in the housing assembly 309. Also, the assembly process does not involve glues, such as black glues, which are difficult to handle. Also, the performance of the IMU 300 is reliable, since the circuit board 305 is disposed in the inner chamber 311 of the weight block assembly 310 along with a compressible thermal interface material 304.

[0039] Figure 4 is an exemplary illustration of a partially assembled inertia measurement unit (IMU), in accordance with various embodiments of the present invention. As shown in Figure 4, a housing assembly 409 in an IMU 400 includes a first housing member 401 and a second housing member 407 that can be mated and locked with each other.

[0040] The IMU 400 can include a weight block assembly 408, which can be configured to have a mass that can keep the inherent frequency of the IMU away from the operation frequency of the unmanned aircraft, e.g. 50~200 Hz.

[0041] The weight block assembly 408 can contain a circuit board (not shown) with various types of sensors that are sensitive to vibration (such as an inertia sensor). Additionally, a flexible signal line 403, which connects to the circuit board in the weight block assembly 408, can be held (or stabilized) on an outside surface (e.g. the top surface) of the weight block assembly 408 to avoid unwanted shift and/or disturbance.

[0042] In accordance with various embodiments of the present invention, the weight block assembly 408 may have different configurations. For example, the weight block assembly 408 can be a single weight block with an inner chamber (or a cavity). Alternatively, the weight block assembly 408 can be formed with multiple members or sections (such as the weight blocks 404-405), which can be tightly coupled to form an inner chamber.

[0043] Additionally, the weight block assembly 408 may be in different geometry shapes. For example, the weight block assembly 408 can be in a cubic shape, a cylinder shape, a spherical shape, an oval shape, a three dimensional polygonal shape, etc.

[0044] As shown in Figure 4, the weight block assembly 408 can be placed in the housing assembly 409 with foams 402 and/or adhesive materials 406, which prevent the weight

block assembly 408 from unnecessary movements. Furthermore, the foams 402 can be configured to reduce the vibration that may affect the performance of the sensors in the IMU 400. Additionally, the foams 402 can ensure that the IMU 400 is working in a satisfactory range of humidity and temperature, which are beneficial in achieving the desired precision in the measurement.

[0045] Figure 5 is an exemplary illustration of an assembled inertia measurement unit (IMU), in accordance with various embodiments of the present invention. As shown in Figure 5, an IMU 500 includes a housing assembly 509 with a first housing member 501 and a second housing member 502 that are mated and locked with each other.

[0046] Furthermore, the housing assembly 509 can be placed on a circuit board 510 using different coupling method, e.g. coupling bolts 506-508. For example, the circuit board 510 may be a control board, or a main circuit board, for an unmanned aircraft. Additionally, the circuit board 510 can include a barometer and necessary heating devices for maintaining a satisfactory temperature for the measurement environment.

[0047] In accordance with various embodiments of the present invention, the IMU 500 can include a weight block assembly 503, which is placed inside the housing assembly 509 (i.e. in an inner chamber within the housing assembly 509). The weight block assembly 509 can be configured to have a mass that can keep the inherent frequency of the IMU away from the operation frequency of the unmanned aircraft (e.g. 50~200 Hz).

[0048] Furthermore, the weight block assembly 503 can include a circuit board (not shown) with an inertia sensor, which can be disposed in an inner chamber in the weight block assembly 503.

[0049] Additionally, a flexible signal line 504 can pass through an opening 511 on the weight block assembly 503 and connects the circuit board in the weight block assembly 503 with the circuit board 510, e.g. using a plug-in device 505. Alternatively the circuit board in the weight block assembly 503 can be electronically connected with the circuit board 510 via different wireless communication protocols.

[0050] Figure 6 is an exemplary illustration of an alternative inertia measurement unit (IMU), in accordance with various embodiments of the present invention. As shown in Figure 6, an IMU 600 includes a weight block assembly 601, which includes a circuit board (not shown) with an inertia sensor. Additionally, the weight block assembly 601 may have different configurations and may be in different shapes.

[0051] In accordance with various embodiments of the present invention, the weight block assembly 601 can be placed directly on a circuit board 610. Alternatively, a vibration attenuation cushion (not shown) can be placed between the weight block assembly 601 and the circuit board 610. Thus, the structure of the IMU 600 can be further simplified and the size of the IMU 600 can be substantially reduced.

[0052] As shown in Figure 6, a flexible signal line 604 can connect the circuit board in the

weight block assembly 603 with a circuit board 610, e.g. using a plug-in device 604. Alternatively, the circuit board in the weight block assembly 601 can be electronically connected with the circuit board 610 via different wireless communication protocols.

[0053] Here, the circuit board 610 can be a control board or a main circuit board for an unmanned aircraft. For example, the circuit board 610 can include a barometer and necessary heating devices to maintain a satisfactory temperature in the measurement environment.

[0054] Figure 7 shows a flowchart of providing a measurement module on a movable object, in accordance with various embodiments of the present invention. As shown in Figure 7, at step 701, a first circuit board may be provided with one or more sensors that support the measurement module. Furthermore, at step 702, a weight block assembly may be provided in the measurement module, wherein the weight block assembly is configured to have a mass that keeps an inherent frequency of the measurement module away from an operation frequency of the movable object. Then, at step 703, said first circuit board can be disposed in an inner chamber of the weight block assembly.

[0055] The foregoing description of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. The breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments. Many modifications and variations will be apparent to the practitioner skilled in the art. The modifications and variations include any relevant combination of the disclosed features. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications and combinations that are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalence.

[0056] While preferred embodiments of the present invention have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the invention. It should be understood that various alternatives to the embodiments of the invention described herein may be employed in practicing the invention. It is intended that the following claims define the scope of the invention and that methods and structures within the scope of these claims and their equivalents be covered thereby.

Claims

[Claim 1] An apparatus for supporting a measurement module, comprising:
a weight block assembly, which is adapted to be placed in the measurement module on a movable object, wherein the weight block assembly is configured to have
a mass that keeps an inherent frequency of the measurement module away from an operation frequency of the movable object, and
an inner chamber, which is adapted to contain a first circuit board with one or more sensors that support the measurement module.

[Claim 2] The apparatus of Claim 1, wherein:
at least one said sensor is an inertia sensor, which includes
one or more velocity measurement instruments,
one or more acceleration measurement instruments,
one or more gyroscopes, and/or
one or more gravity gradiometers.

[Claim 3] The apparatus of Claim 1, wherein:
the movable object is a unmanned aircraft, a unmanned vehicle, a hand held device, or a robot.

[Claim 4] The apparatus of Claim 1, further comprising:
a thermal interfacing material, which is filled in a gap in the inner chamber within the weight block assembly, wherein the thermal interfacing material is adapted to
conduct heat away from the first circuit board, and
prevent the first circuit board from moving inside the inner chamber within the weight block assembly.

[Claim 5] The apparatus of Claim 4, wherein:
the thermal interfacing material is selected from a group consisting of silica gel, thermal gel, epoxy, phase change materials, polyimide, graphite, aluminum tapes, and silicone-coated fabrics.

[Claim 6] The apparatus of Claim 1, further comprising:
a second circuit board, wherein the second circuit board operates to communicate with the first circuit board in the weight block assembly.

[Claim 7] The apparatus of Claim 6, further comprising:
a signal line that passes through an opening of the weight block assembly and connects the first circuit board with the second circuit board.

[Claim 8] The apparatus of Claim 7, wherein:

the signal line is stabilized on an outside surface of the weight block assembly.

[Claim 9] The apparatus of Claim 6, wherein:
the weight block assembly, which contains the first circuit board, is placed on the second circuit board.

[Claim 10] The apparatus of Claim 1, wherein:
the weight block assembly comprises multiple sections that are tightly coupled together to form the inner chamber within the weight block assembly.

[Claim 11] The apparatus of Claim 10, wherein:
the first circuit board is coupled with a section of the weight block assembly.

[Claim 12] The apparatus of Claim 1, further comprising:
a housing assembly, wherein the housing assembly comprises a first housing member and a second housing member, which are adapted to be locked together.

[Claim 13] The apparatus of Claim 12, wherein:
the weight block assembly is positioned on an inner surface of the housing assembly using a positioning device and fixed in the housing assembly using an adhesive material and/or a foam.

[Claim 14] The apparatus of Claim 12, wherein:
the housing assembly is placed on a part of the movable object.

[Claim 15] A method for assembling a measurement module for a movable object, comprising:
providing a first circuit board with one or more sensors that support the measurement module;
providing a weight block assembly in the measurement module, wherein the weight block assembly is configured to have a mass that keeps an inherent frequency of the measurement module away from an operation frequency of the movable object, and
disposing said first circuit board in an inner chamber within the weight block assembly.

[Claim 16] The method of Claim 15, wherein:
at least one said sensor is an inertia sensor, which includes
one or more velocity measurement instruments,
one or more acceleration measurement instruments,
one or more gyroscopes, and/or
one or more gravity gradiometers.

[Claim 17] The method of Claim 15, wherein:
the movable object is a unmanned aircraft, a unmanned vehicle, a hand held device, or a robot.

[Claim 18] The method of Claim 15, further comprising:
filling a thermal interfacing material in a gap in the inner chamber within the weight block assembly, wherein the thermal interfacing material is adapted to
conduct heat away from the first circuit board, and
prevent the first circuit board from moving inside the inner chamber within the weight block assembly.

[Claim 19] The method of Claim 18, wherein:
the thermal interfacing material is selected from a group consisting of silica gel, thermal gel, epoxy, phase change materials, polyimide, graphite, aluminum tapes, and silicone-coated fabrics.

[Claim 20] The method of Claim 15, further comprising:
providing a second circuit board, wherein the second circuit board operates to communicate with the first circuit board in the weight block assembly.

[Claim 21] The method of Claim 20, further comprising:
passing a signal line through an opening of the weight block assembly and connects the first circuit board with the second circuit board.

[Claim 22] The method of Claim 21, further comprising:
stabilizing the signal line on an outside surface of the weight block assembly.

[Claim 23] The method of Claim 20, further comprising:
placing the weight block assembly, which contains the first circuit board, on the second circuit board.

[Claim 24] The method of Claim 15, wherein:
the weight block assembly comprises multiple sections that are tightly coupled together to form the inner chamber within the weight block assembly.

[Claim 25] The method of Claim 24, further comprising:
coupling the first circuit board with a section of the weight block assembly before said multiple sections are coupled together.

[Claim 26] The method of Claim 15, further comprising:
providing a housing assembly, wherein the housing assembly comprises a first housing member and a second housing member, which are adapted to be locked together.

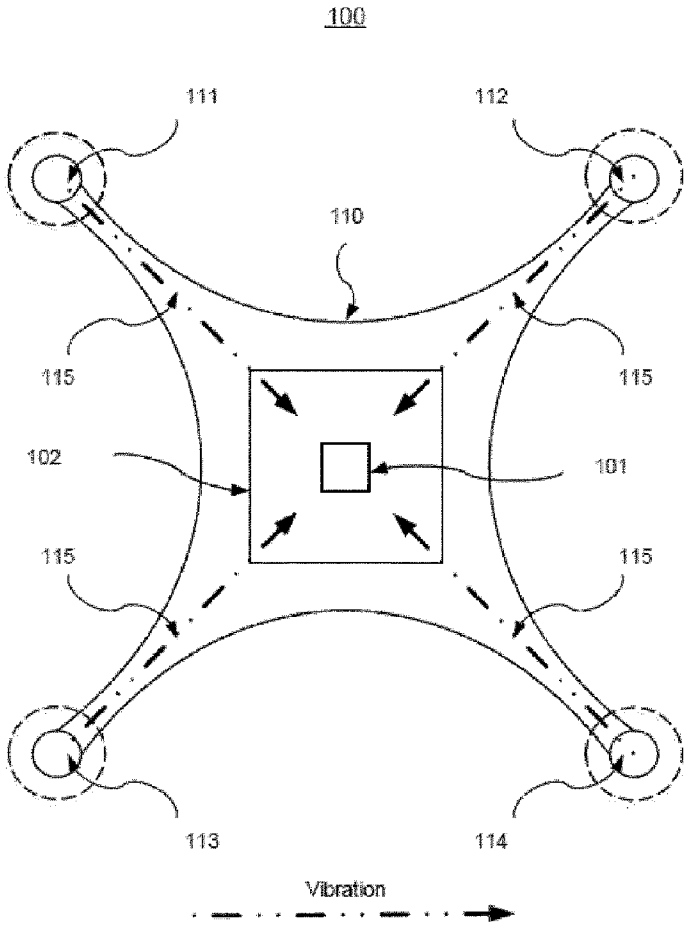
[Claim 27] The method of Claim 26, further comprising:
using a positioning device to position the weight block assembly on an inner surface of the housing assembly, and
using an adhesive material and/or a foam to fix the weight block assembly in the housing assembly.

[Claim 28] The method of Claim 26, further comprising:
placing the housing assembly on a part of the movable object.

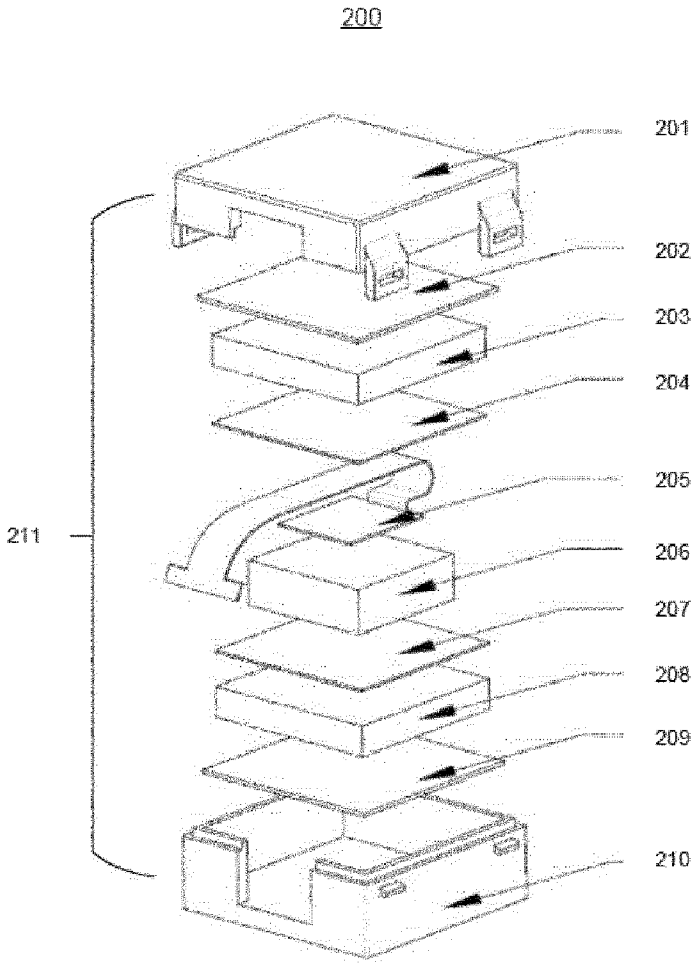
[Claim 29] A measurement module, comprising:
a first circuit board with one or more sensors that support the measurement module; and
a first weight block and a second weight block in the measurement module, wherein the first weight block and the second weight block are configured to have a total mass that keeps an inherent frequency of the measurement module away from an operation frequency of the movable object, and
wherein said first circuit board is disposed in an inner chamber that is formed between the first weight block and the second weight block.

[Claim 30] A method for assembling a measurement module for a movable object, comprising:
providing a first circuit board with one or more sensors that support the measurement module;
providing a first weight block and a second weight block, wherein the first weight block and the second weight block are configured to have a total mass that keeps an inherent frequency of the measurement module away from an operation frequency of the movable object; and
disposing the first circuit board in an inner chamber that is formed between the first weight block and the second weight block.

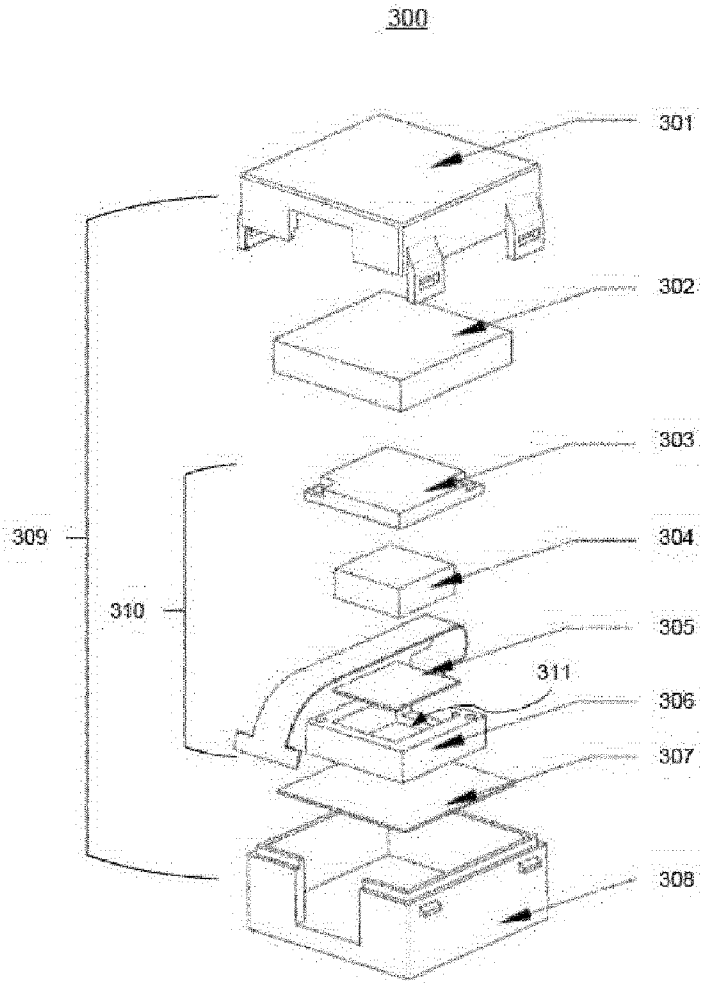
[Fig. 1]



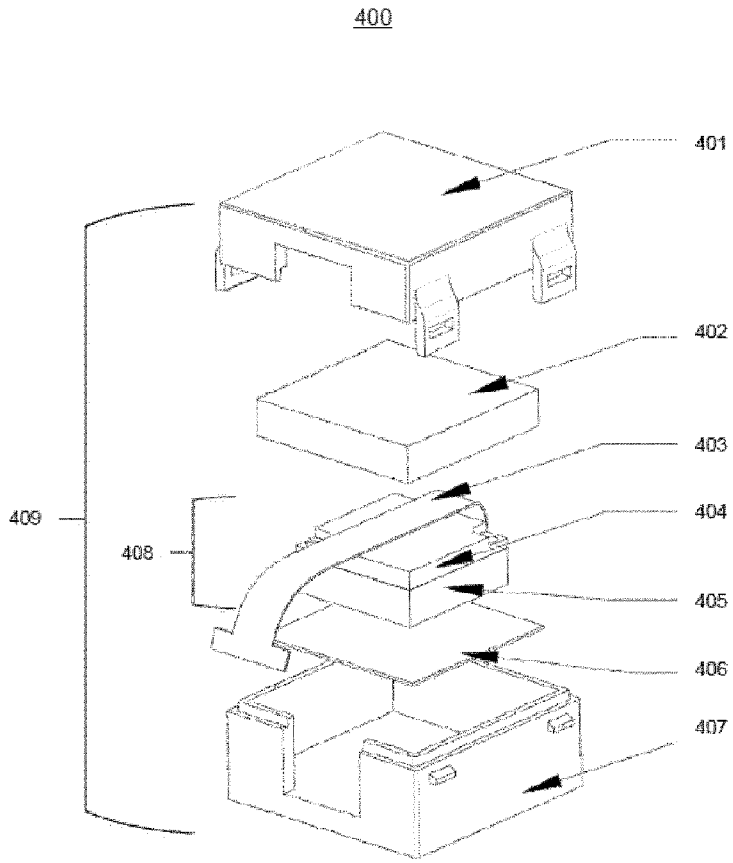
[Fig. 2]



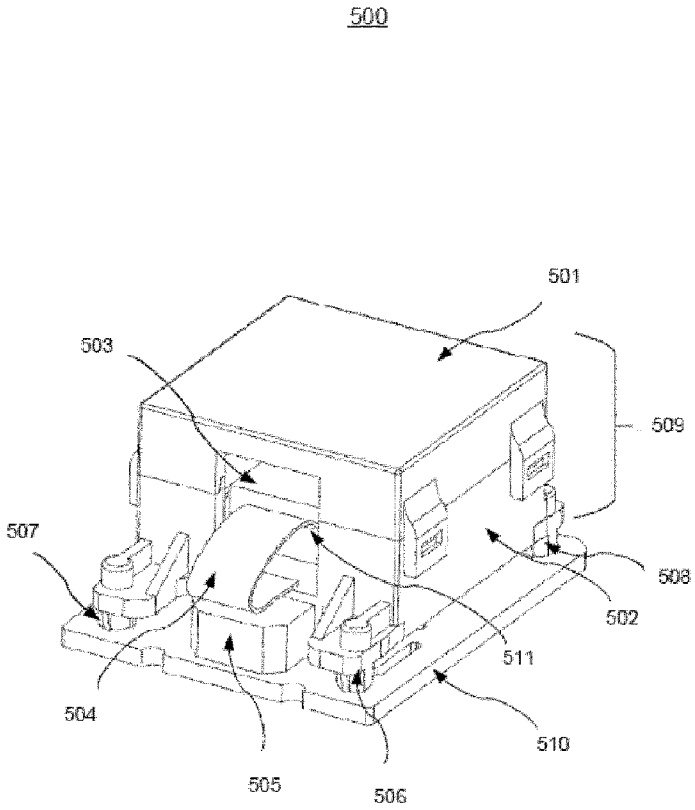
[Fig. 3]



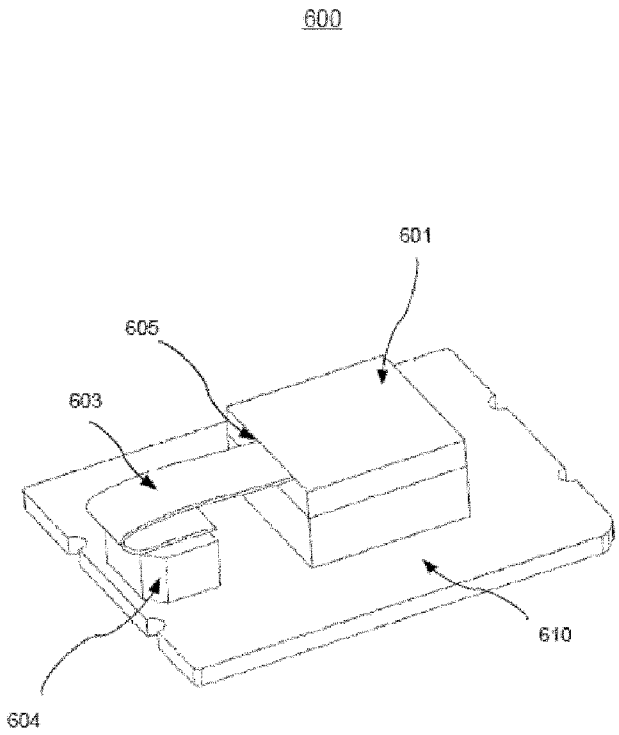
[Fig. 4]



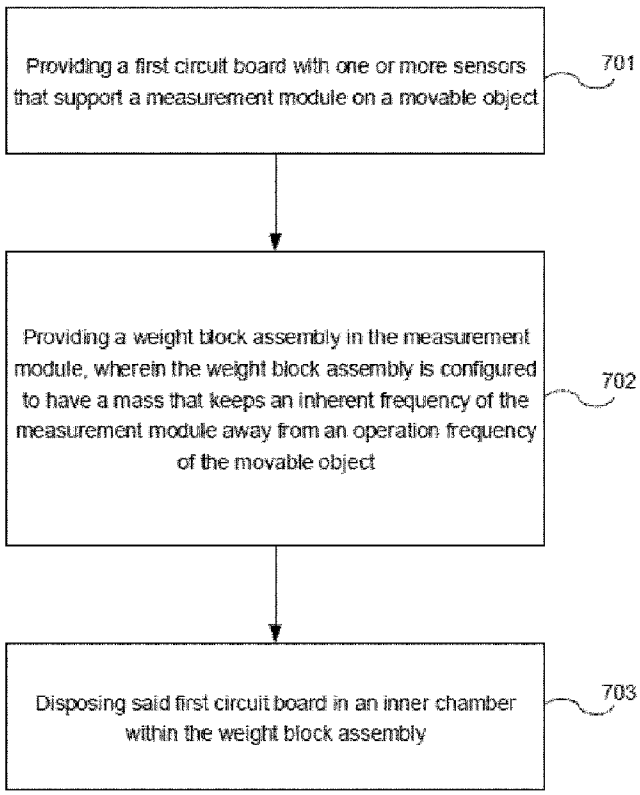
[Fig. 5]



[Fig. 6]



[Fig. 7]


Providing a first circuit board with one or more sensors that support a measurement module on a movable object
701
Providing a weight block assembly in the measurement module, wherein the weight block assembly is configured to have a mass that keeps an inherent frequency of the measurement module away from an operation frequency of the movable object
702
Disposing said first circuit board in an inner chamber within the weight block assembly
703

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/076012

A. CLASSIFICATION OF SUBJECT MATTER

G01C 21/16(2006.01)i; G01C 21/24(2006.01)i; G01C 19/00(2013.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01C 19; G01C 21; G01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNKI, CNTXT, VEN, USTXT, EPTXT, WOTXT: inertia, imu, mass, weight, block, circuit board, chamber?, cavity, frequency, aircraft?, aerocraft

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102980584 A (SZ DJI TECHNOLOGY CO., LTD.) 20 March 2013 (2013-03-20) the description, paragraphs [0031] to [0045], and figures.1-5	1-9, 12-23, 26-28
Y	CN 102980584 A (SZ DJI TECHNOLOGY CO., LTD.) 20 March 2013 (2013-03-20) the description, paragraphs [0031] to [0045], and figures.1-5	10, 11, 24, 25, 29, 30
X	CN 202274882 U (SZ DJI TECHNOLOGY CO., LTD.) 13 June 2012 (2012-06-13) the description, paragraphs [0031] to [0045], and figures.1-5	1-9, 12-23, 26-28
Y	CN 203249935 U (HANGZHOU YIHENG TECHNOLOGY CO., LTD.) 23 October 2013 (2013-10-23) the description, paragraph [0016], and figure 1	10, 11, 24, 25, 29, 30
A	CN 103210280 A (SZ DJI TECHNOLOGY CO., LTD.) 17 July 2013 (2013-07-17) the whole document	1-30
A	JP 2002022761 A (MATSUSHITA DENKI SANGYO KK.) 23 January 2002 (2002-01-23) the whole document	1-30

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 January 2016	**20 January 2016**
Name and mailing address of the ISA/CN **STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China** Facsimile No. **(86-10)62019451**	Authorized officer **YANG,Shilin** Telephone No. **(86-10)62085717**

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2015/076012

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5239866 A (ASULAB S.A.) 31 August 1993 (1993-08-31) the whole document	1-30

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2015/076012

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	102980584	A	20 March 2013	WO	2013029286	A1	07 March 2013
				US	2014224014	A1	14 August 2014
				EP	2752643	A1	09 July 2014
				JP	2014526998	A	09 October 2014
				EP	2752643	A4	29 April 2015
CN	202274882	U	13 June 2012		None		
CN	203249935	U	23 October 2013		None		
CN	103210280	A	17 July 2013	JP	2013540987	A	07 November 2013
				CN	103210280	B	17 June 2015
				EP	2604974	A1	19 June 2013
				CN	104964687	A	07 October 2015
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				EP	2604974	B1	08 July 2015
				CN	102121829	B	12 June 2013
				CN	102121829	A	13 July 2011
				EP	2604974	A4	07 May 2014
				WO	2011140804	A1	17 November 2011
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US	5239866	A	31 August 1993	FR	2666888	A1	20 March 1992
				JP	H04297837	A	21 October 1992
				EP	0476482	B1	25 January 1995
				DE	69106987	D1	09 March 1995
				FR	2666888	B1	15 April 1994
				EP	0476482	A1	25 March 1992