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(71) Applicant *(for all designated States except US)*: **QUALCOMM INCORPORATED** [US/US]; Attn: International IP Administration, 5775 Morehouse Drive, San Diego, California 92121 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **KRULCE, Darrell L.** [US/US]; 5775 Morehouse Drive, San Diego, California 92121 (US). **TIAN, Bin** [US/US]; 5775 Morehouse Drive, San Diego, California 92121 (US).

(74) Agent: **BACHAND, Richard A.**; 5775 Morehouse Drive, San Diego, California 92121 (US).

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(54) Title: METHOD FOR DETERMINING THE NULL POINT OF A GYROSCOPE

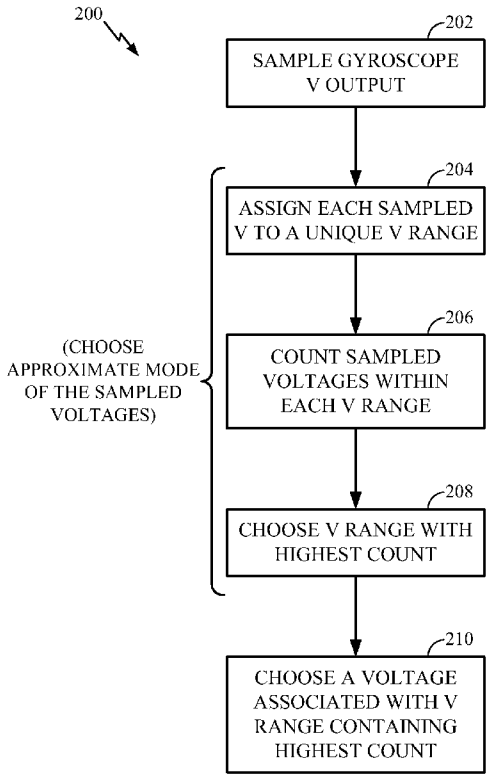

FIG. 2

(57) Abstract: A system for correcting angular velocity measurements from a gyroscope (104) and using the corrected angular velocity measurements to position an antenna (106) used with a vehicle. (102) The system determines an approximate null point voltage of a gyroscope of the type that produces a voltage related to an angular velocity to be measured by the gyroscope. (104) The approximate null point is determined by sampling the output voltage to obtain a plurality of sampled voltages and choosing an approximate mode of the plurality of sampled voltages as the approximate null point voltage.

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METHOD FOR DETERMINING THE NULL POINT OF A GYROSCOPE

BACKGROUND

Field

[0001] This disclosure relates generally to systems and methods for determining a null point of a gyroscope, and more particularly, to methods and systems of the type described which may be used in an antenna position control system in conjunction with a moving vehicle.

[0002] Gyroscopes are widely known and used for navigation, direction finding, and other purposes. Gyroscopes of the type used for such purposes typically produce an output voltage that is relatable to the angular velocity to which the gyroscope is exposed so that as the gyroscope is rotated the amount of rotation can be determined. When a gyroscope of this type is not rotating, it typically produces a quiescent output voltage that is referred to as its "null point" voltage, or simply its "null point." As the gyroscope is rotated, its output voltage varies in a known manner with respect to the null point. Consequently, in the design of a system that relies upon the output voltage of a gyroscope, the null point must be accurately determined.

[0003] Unfortunately, many factors can affect the accuracy of the null point determination and introduce serious error into any system that uses the gyroscope information. For example, the manufacturing process itself often creates variations in the null point from one gyroscope to another. It would be costly to purchase any number of gyroscopes from a manufacturer to find a few with very close null points, that is, where each gyroscope has a null point almost identical to the null points of the other gyroscopes. Environmental factors, such as temperature and humidity, also can affect the accuracy of the null point determination. Even if the null point of a single gyroscope were known with precision, many gyroscopes include integrated circuits that may be affected by temperature and humidity changes. Power supply variations, particularly in mobile applications, also can affect the accuracy of the null point determination.

[0004] Even a small error in the null point can result in large errors in systems that rely on the gyroscope output. For example, if due to the use of an inaccurate null point the angular velocity measured by the gyroscope is off by 7 degrees, then this would be

integrated as 7 degrees per second. Therefore, as the time of integration increases, the error would increase 7 degrees every second. Thus, the error would be 7 degrees after 1 second, 14 degrees after two seconds, and so on. It can be seen that at some point any calculation based on the inaccurate measurement would result in a final value that may be highly inaccurate. Consequently, gyroscope manufacturers sometimes go to great lengths to correct the gyroscope output to account for the various factors, temperature, supply voltage variations, and various other factors, that may influence its accuracy.

[0005] One application for gyroscopes of the type described is to position antennas on moving vehicles, such as trucks, planes, aircraft, spacecraft, trains, automobiles, construction equipment, watercraft, and the like. For example, shipping companies often have a need to communicate with their delivery vehicles as they travel throughout the country, for example, through the use of a satellite communication system. In this type of system an antenna carried on the vehicle is continuously positioned to track the satellite to send and receive communication signals therefrom. As the vehicle moves, typically a gyroscope is used to measure the angular velocity of the vehicle and produce a voltage representative of the measured angular velocity. A servo system is used to change the position of the antenna according to the output voltage from the gyroscope to keep it locked to the satellite.

[0006] Initially, it is necessary to position the antenna to acquire the satellite signal (satellite acquisition phase). One method which has been used is to move the antenna through a 360 degree arc, while taking signal strength measurements at various points throughout the arc. The antenna can then be positioned towards the satellite, based on the strongest signal strength measurement taken. If the vehicle is turning during the satellite acquisition phase, the angular velocity measurement of the gyroscope can be used to ensure that the antenna is moved through the full 360 degree arc.

[0007] Once the satellite is acquired, the position of the antenna needs to be continuously monitored to maintain its position to track the satellite. This is difficult when the vehicle is moving in essentially random directions with respect to the satellite, and the difficulty is exacerbated by the difficulty in maintaining the accuracy of the null point determination.

[0008] What is needed is a method for determining the null point of a gyroscope, particularly of gyroscopes of the type used in the positioning of a communication antenna, or the like.

SUMMARY

[0009] Disclosed are methods for determining a null point of a gyroscope of the type that produces a voltage related to an angular velocity to be measured by the gyroscope. In one embodiment, a method is provided that includes sampling the output voltage of the gyroscope to obtain a plurality of sampled voltages and choosing an approximate mode of the plurality of sampled voltages as the null point voltage. An advantage to this approach is that an external reference source, such as a satellite, tower, or the like, is not needed. Another advantage is that it does not matter if the angular velocity is changing or constant, the null point can still be quickly and easily calculated.

[0010] In another embodiment for determining the null point of a gyroscope, the output voltage is sampled to obtain a plurality of sampled voltages, assigning each sampled output voltage to a respective one of a plurality of bins, each bin representing a voltage range wherein each sampled output voltage is contained, counting a number of sampled output voltages in each bin, determining the bin with a highest count of sampled voltages, and selecting an associated voltage corresponding to a bin with the highest count of sampled voltages.

[0011] Also disclosed is an apparatus for determining a null point voltage of a gyroscope of the type that produces an output voltage related to an angular velocity to be measured by the gyroscope. The apparatus includes means for sampling the output voltage to obtain a plurality of sampled voltages and means for selecting an approximate mode of the plurality of sampled voltages as the null point voltage.

[0012] Also disclosed is a computer-readable media, which when executed by a processor, operates to determine a null point of a gyroscope. The media includes instructions for sampling the output voltage to obtain a plurality of sampled voltages, and for choosing an approximate mode of the plurality of sampled voltages as the null point voltage.

[0013] Also disclosed is a method for positioning an antenna during a satellite acquisition phase. The method includes sampling a voltage of a gyroscope related to an angular velocity measured by the gyroscope to obtain a plurality of sampled voltages, choosing an approximate mode of the plurality of sampled voltages as the null point voltage, moving the antenna through a 360 degree arc, using the calculated null point of the gyroscope to verify that the antenna moved through a full 360 degree arc, taking satellite energy measurements at discrete points throughout the full 360 degree arc, and

positioning the antenna towards the satellite based on a strongest satellite energy measurement.

[0014] Also disclosed is a method for positioning an antenna used with a vehicle while the vehicle is changing directions. The method includes sampling an output voltage of a gyroscope related to an angular velocity measured by the gyroscope to obtain a plurality of sampled voltages, choosing an approximate mode of the plurality of sampled voltages as the null point voltage, moving the antenna in a first direction based upon the chosen null point, taking a first satellite energy measurement, moving the antenna in a second direction based upon the chosen null point, taking a second satellite energy measurement, comparing the first satellite energy measurement to the second satellite energy measurement to see which is stronger; and positioning the antenna based on the stronger energy measurement.

[0015] Also disclosed is a system for positioning an antenna used with a vehicle. The system includes a gyroscope for producing a voltage based on an angular velocity, means for sampling the voltage to obtain a plurality of sampled voltages, means for choosing an approximate mode of the plurality of sampled voltages as the null point voltage, and means for positioning the antenna based on the chosen null point.

[0016] Also disclosed are a system and method for correcting angular velocity measurements from a gyroscope of the type that produces a voltage related to the angular velocity. The system and method may be used, for example, to position an antenna that may be carried on a moving vehicle. For example, in one embodiment, a rotatable antenna is carried on a truck to enable communications via a satellite to a remote station. In order to correctly position the antenna towards the satellite, the approximate null point of the gyroscope is determined. The method comprises sampling the gyroscope voltage to obtain a plurality of sampled voltages and choosing an approximate mode from among the plurality of sampled voltages as the null point. The null point can then be subtracted from the gyroscope output to get a relatively accurate voltage which represents a corrected angular velocity. The corrected angular velocity can then be used to position the antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 shows an environment in which a system for positioning an antenna used with a vehicle may be employed;

[0018] FIG. 2 shows a flow chart for one embodiment of a method to determine the null point of a gyroscope;

[0019] FIG. 3 shows a flow chart of an embodiment of a method for positioning an antenna used with a vehicle towards a preacquired satellite;

[0020] FIG. 4 shows a flow chart of an embodiment of a method for positioning an antenna during a satellite acquisition phase;

[0021] FIG. 5 shows a functional block diagram of an embodiment of an apparatus used to determine the null point of a gyroscope;

[0022] FIG. 6 shows a functional block diagram of an embodiment of a method for using a null point of a gyroscope to correct the angular velocity measurement of the gyroscope in positioning an antenna used with a vehicle;

[0023] FIG. 7 shows a functional block diagram of a computer implementation of a method for positioning an antenna used with a vehicle.

[0024] In the various figures of the drawing, like reference numbers are used to denote like parts, steps, or functions.

DETAILED DESCRIPTION

[0025] FIG. 1 shows an environment 100 in which a system of the type described may be used for positioning a communication antenna used with a truck 102. The truck 102 carries a gyroscope 104, an antenna 106, and a servo 108, enclosed by an enclosure 110 to protect the various parts from environmental conditions. It should be understood that although the description herein is illustrated in the context of a truck 102, the principles can be applied to any type of vehicles or movable platform, such as, for instance, trucks, planes, aircraft, spacecraft, trains, automobiles, construction equipment, watercraft, and the like. The truck 102 can communicate with a remote station 114 via an antenna 106 and a communication satellite 112. The remote station 114 may be a, for example, a fleet dispatch station, an intermediate hub, an operations center, or other facility with which communications are desired. As an example, the remote station 114 may be a backend truck dispatcher, a tracking facility, or the like.

[0026] The gyroscope 104 may be electrical, mechanical, a combination of both, or a semiconductor device. For example, Analog Devices manufactures a semiconductor angular rate sensor (gyroscope), model number ADXRS401 which may be used.

[0027] The antenna 106 may be of the type that rotates through all or part of a 360 degree arc, and may facilitate both transmit and receive functions. The antenna 106 may be moved to a desired position by the servo 108 which includes a motor to drive the antenna 106 to the desired position. The degree of exactness of the movements of the antenna 106 depends at least in part on the preciseness of the servo used. For instance, if the servo 108 used can move in 5 degree increments, then the movement of the antenna 106 by the servo 108 will be limited to 5 degree increments also.

[0028] The position of the antenna 106 is controlled by the gyroscope 104 and the servo 108. The gyroscope 104 is used with the truck 102 to determine if the vehicle is changing directions, and if so, by how much. For example, the servo 108 may include a stepper-motor, and the position of the antenna relative to the vehicle 102 can be controlled by the number of steps the servo 108 makes. Then, using the direction of the truck 102 and the position of the antenna 106, the actual direction in which the antenna 106 is pointing and any necessary changes that need to be made using the servo 108 to reposition the antenna 106 can be determined.

[0029] FIG. 2 shows a flow chart 200 for an embodiment of a method to determine the null point of the gyroscope 104. The method begins at block 202 where the voltage output (V output) of the gyroscope 104 is sampled to obtain a plurality of sampled voltages. At block 204, each sampled voltage is assigned to one of a plurality of unique voltage ranges (V ranges). The V ranges are determined by dividing the entire voltage range that can be provided at the output of the gyroscope 104 into a plurality of adjacent ranges. Although the number of ranges that are provided is a matter of design choice, the resolution of the null point determination depends on the number and width of the ranges that are defined. Consequently, the more V ranges that are defined, the higher the resolution of the null point determination, and the higher the accuracy of the gyroscope 104 that can be achieved.

[0030] At block 206, the sampled voltages that have been assigned to each V range are counted. Although shown as a discrete step, the counting of the number of sampled voltages assigned to each V range may be performed continuously as each sample is taken, or may be counted periodically. If the voltages within each V range are counted after each sample is taken, the null point may be corrected more frequently than if the count were performed periodically. Thus, the frequency of the counting can be determined in accordance with the needs of a particular application. For example, the

frequency of the counting could be based on the clock speed of the processor used, or it could be based on how frequently it was desired to make a decision to move the antenna 106.

[0031] At block 208, the V range with the highest count of sampled voltages assigned to it is chosen or determined. The V range with the highest count represents the approximate mode of the sampled voltages, and is used to represent the approximate null point of the gyroscope 104. It can be seen that the accuracy of the null point approximation is dependent upon the width of the individual V ranges that are employed. However, typical servos can only move a finite number of degrees, and this limits the fine adjustments that can be made to the antenna position. Therefore, it would not be necessary to have an infinite number of V ranges, because even if a very specific voltage could be obtained, the servo used may not be able to make a move corresponding to the angular velocity that the voltage represents.

[0032] The frequency at which the highest count is determined depends on the user's application. For example, if the approximate mode is determined after each sample is taken, the gyroscope voltage could be corrected more frequently than if the approximate mode were only chosen periodically. Thus, for example, if it is desired to move an antenna 106 via the servo 108 frequently, a higher frequency might be used, for example, after each sample is taken, than if the antenna were to be moved every few seconds.

[0033] As noted, in blocks 204, 206, 208 the approximate mode of the sampled gyroscope output voltages is chosen. Once the approximate mode is found, it can be subtracted from the voltage output of the gyroscope 104 to obtain a corrected output voltage. This corrected output voltage represents an accurate angular velocity measurement from the gyroscope 104 which is substantially independent of temperature, humidity, power supply voltages, and other environmental factors to which the gyroscope may be exposed.

[0034] At block 210, a voltage associated with the range containing the highest count is chosen. This associated voltage represents the approximate null point of the gyroscope. Depending upon the width of the V ranges that are employed, a predetermined voltage within each V range may be selected as the associated voltage; that is, a single voltage may be used that will represent the entire V range. There are many ways to select the associated voltage. For instance, the low or high voltage of each range may be selected

to represent the entire respective range with which it is associated. For greater precision, the low voltage of the range may be added to the high voltage of the range to obtain a voltage sum, and then the voltage sum may be divided by a predetermined number to obtain a result to represent the associated voltage. The predetermined number could be any number, for instance two, or any other number. Another way to select the associated voltage is to find an average of all of the sampled voltages within each discrete voltage range. It should be understood by those skilled in the art that there are many other ways to select the associated voltage.

[0035] As an example, two voltage ranges may be chosen, the first from 0 Volts to + 1.0 Volts, and a second from +1.1 Volts to 2.0 Volts. All voltages in this example would be rounded up to the nearest 0.1 volts. It would then be determined after a certain number of samples from the gyroscope were taken, which voltage range had the highest count of sampled voltages. Assume that the highest count of sampled voltages were in the first voltage range. A voltage within the first voltage range would then be chosen to represent the first voltage range. For example, +1.5 Volts could be chosen to represent the voltage range, and, therefore, the null point of the gyroscope.

[0036] FIG. 3 shows a flow chart of an embodiment 300 of a method for positioning an antenna 106 used with a vehicle towards a preacquired satellite 112. The method begins at block 202 where the gyroscope output is sampled, and in a manner similar to that described above, assigned to one of a plurality of voltage ranges (V ranges). At block 206, the sampled voltages in each V range are counted.

[0037] At block 210, the voltage associated with a voltage range containing the highest count of sampled voltages is chosen as the approximate mode of the sampled voltages. At block 302, a first satellite energy measurement is taken at a first antenna position, by any known means. At block 304, the antenna 106 is moved to a second selected position. At block 306, a decision is made; using the approximate mode, to verify whether the antenna was moved to the correct second selected position. If the antenna 106 did not move to the correct position, then the method is repeated from block 304 to again move the antenna to the second selected position. If, however, the antenna 106 did move to the correct position, then the method proceeds to block 308 where a second satellite energy measurement is made.

[0038] At block 310, a decision is made to determine if the first energy measurement taken was stronger than the second energy measurement taken. If the first energy

measurement was not stronger than the second energy measurement the method goes back to block 302 to again take a first satellite energy measurement at a first antenna position. If the first energy measurement was stronger than the second energy measurement, then the method proceeds to block 312, and the antenna 106 is moved towards the first (stronger) energy measurement. After block 312, the whole method repeats starting back at block 202 where the gyroscope 104 output is sampled.

[0039] FIG. 4 shows a flow chart of an embodiment 400 of a method for positioning an antenna 106 during a satellite acquisition phase 400. The method begins at block 202 where the gyroscope output is sampled, and in a manner similar to that described above, assigned to one of a plurality of voltage ranges (V ranges). At block 206, the sampled voltages in each V range are counted. At block 210, the voltage associated with the V range containing the highest count of sampled voltages is chosen as the approximate mode. At block 402, the antenna is moved to a predetermined position. At block 404, using the approximate mode, it is verified that the antenna 106 moved to the desired predetermined position. For example, if antenna 106 was to be moved 25 degrees to the left, the servo would be instructed to move to that position.

[0040] At block 406, a decision is made whether the antenna 106 was moved to the correct predetermined position using the output of the gyroscope 104 to verify whether the antenna 106 was in fact moved 25 degrees to the left. The method then proceeds to block 410 where a satellite energy measurement is taken. If the antenna 106 was not moved to the correct position, then the method proceeds to block 408 to move the antenna 106 to the correct position, and then to block 404 to again verify that the antenna 106 was moved to the correct predetermined position.

[0041] After a satellite energy measurement is taken at block 410, a decision is made at block 412; using the approximate mode, if energy measurements have been made through a complete 360 degree arc. Then at block 414 the antenna 106 is positioned towards a satellite 112 based on the strongest energy measurement. As in the previous example, the antenna 106 can be moved via the servo 108, and then the position of the antenna verified to insure that the antenna moved to the predetermined position; in this case, some percentage of a 360 degree arc. If energy measurements have not been made through a complete 360 degree arc, then the method returns to block 402, and the antenna 106 is again moved to a pre-determined position.

[0042] FIG. 5 shows a functional block diagram of an embodiment of an apparatus 500 used to determine the null point of a gyroscope 106. It will be appreciated that blocks 502, 504, 506, 508, and 510, may be implemented in any one of a number of ways. For example they may be discrete components, as parts of a bigger circuit using logical components, as all or part of a software embodiment, or the like. The techniques and configurations disclosed may be implemented as ASIC's, FPGA's, or some other hardware-software combination.

[0043] The apparatus 500 has a gyroscope 104 having an output that is connected to a sampler 502. The sampler 502 may be implemented via a physical circuit, a logical circuit, firmware, and the like. It may be part of an A/D Converter (analog to digital converter). The sampler 502, if part of an A/D converter, will sample an analog voltage output of a gyroscope 104 and then convert it to a digital signal.

[0044] The samples are counted by counter 504, based on where they fall within respective discrete voltage ranges. In order to keep the number of counts accumulated manageable, a count reducer 506 may be used to lower any counts made. This can be done at predetermined or random time intervals, or at a predetermined or random number of accumulated counts.

[0045] An approximate mode of the counted samples is selected by mode selector 510. The mode selector 510 uses the associated voltage selector 508, and the count from the counter 504 to choose a voltage associated with the voltage range with the highest count of sampled voltages as the approximate mode.

[0046] FIG. 6 shows a functional block diagram 600 of an embodiment of a method for using a null point of a gyroscope to correct the angular velocity measurement of the gyroscope in positioning an antenna used with a vehicle 102. The gyroscope 104 is connected to an A/D converter 602. If the gyroscope 104 is of the type that outputs a digital voltage, then the A/D converter 602 would not be needed, and the gyroscope 104 would be connected directly to the sampler 502. The sampler 502 samples the digital voltage output of the A/D converter 602(or from the gyroscope 104 if an A/D converter 602 is not needed). It will be understood that there are numerous ways to sample a digital voltage, as well as numerous ways of configuring a sampler. For instance, a discrete electrical circuit may be used, or the sampler may be part of a larger circuit that may or may not include the A/D converter 602. The sampling rate is chosen based on

normal engineering design considerations. For instance, the sampling rate may be 600 times per second, or any other appropriate sampling rate.

[0047] The output of the sampler 602 is connected to a sorter 604 and to a subtracter 614, described below. Sorter 604 separates the sampled voltages into discrete bins 606. Each bin 606 has a low voltage (L), a high voltage (H), and a single voltage which represents the bin (V). The number of bins will vary depending on the application, as well as the voltage range of each bin. For example, the positive output of an ADXRS401 gyroscope may be used and may be configured to output an approximate voltage that varies between 0.625 Vdc and 4.375 Vdc where 2.5 Vdc is nominal. If 512 bins were desired, then each bin would have approximately a 7.32 mV voltage range ((4.375V-0.625V) / 512 bins = 7.32mV). The sorter assigns each voltage sampled to the bin whose voltage range contains the sampled voltage.

[0048] The bin counter 608 counts the number of samples the sorter 602 assigns to each bin. As the number of counts accumulates, the number may be reduced by a divider 610 to make the count more manageable. This can be done at predetermined times, or at predetermined counts, or as needed by the user's application. As an example, the count in each bin could be divided by 2 every 2 minutes.

[0049] A high count selector 612 selects the representative or associated voltage (V) of the bin with the highest count of sampled voltages as the approximate null point of the gyroscope 104. This can be done at any desired frequency. As an example, the approximate null point could be determined 600 times per second, corresponding to the sampling rate described above. Since the approximate null point of the gyroscope 104 chosen from the bin containing the highest count of sampled voltages is the statistical approximate mode of all the samples taken at some point in time, the approximate null point has already been error corrected. That is, the null point of the gyroscope 104 has been calculated without relying on the predicted null point of the gyroscope 104, as stated by the manufacturer of the gyroscope 104. Therefore, any error in the manufacturer's stated null point due to temperature, humidity, and other environmental or external factors, has been substantially eliminated.

[0050] The subtracter 614 is used to reduce the error of sampled voltages caused by an inaccurate null point. The subtracter 614 reduces the error of sampled voltages by subtracting the approximate null point voltage from a sampled voltage to obtain a difference voltage. The difference voltage represents the sampled voltage that has been

error corrected. Since the voltage from the gyroscope 104 corresponds to an angular velocity measured by the gyroscope 104, the error corrected voltage sample represents an angular voltage that has also been error corrected.

[0051] The voltage to angular velocity converter 616 is used to convert the difference voltage into its corresponding angular velocity. The angular velocity is mathematically integrated in block 618, the result of the integration representing an angle measurement. That is, the angle represents the change in the direction of travel of the truck 102 as measured by the gyroscope 104.

[0052] The results of the mathematical integration from the integrator 618 are stored in the result storer 620. The difference (error) between the last angle measured and the current angle measurement are calculated in the error comparer 622. When the error calculated in the error comparer 622 is more than a predetermined threshold, the servo 108 is instructed to move the antenna 106. The predetermined threshold can be chosen based on the user's application. For example, the threshold could be set to 2/3 (.667) grads. In this example, if the error between the last angle measured and the current angle measurement was more than 2/3 grad, then the stepper motor would be instructed to move 1-full grad, i.e. re-position the antenna by 1-full grad.

[0053] FIG. 7 shows a functional block diagram 700 of a computer implementation of a method for positioning an antenna used with a vehicle. A gyroscope 104 that produces a voltage in proportion to an angular velocity measured by the gyroscope is connected to an A/D Converter 602 (if necessary). The A/D Converter converts the analog signal from the gyroscope 104 into a digital voltage to be used by the CPU 702. The CPU 702 performs any necessary calculations and may store any intermediary or final results in memory 704. Once the signals are processed by the CPU 702 they may be used to instruct a servo 108 to move an antenna 106 used with a vehicle.

[0054] It will be appreciated by those skilled in the art that any method steps described above can be interchanged without departing from the scope of the invention.

CLAIMS

We claim:

1. A method for determining a null point voltage of a gyroscope that produces an output voltage related to an angular velocity to be measured by the gyroscope, comprising:

sampling the output voltage to obtain a plurality of sampled voltages; and

choosing an approximate mode of the plurality of sampled voltages as the null point voltage.

2. The method of claim 1 wherein said choosing comprises counting the sampled voltages which fall within respective discrete voltage ranges and choosing a voltage associated with a discrete voltage range containing the highest count of sampled voltages.

3. The method of claim 2 wherein each discrete voltage range has a low voltage and a high voltage.

4. The method of claim 3 further comprising selecting a predetermined voltage from each discrete voltage range to be the associated voltage.

5. The method of claim 3 wherein said associated voltage is determined for each discrete voltage range by adding the low voltage to the high voltage to obtain a voltage sum and dividing the voltage sum by a predetermined number.

6. The method of claim 5 wherein the predetermined number is 2.

7. The method of claim 3 wherein the associated voltage is an average of all of the sampled voltages within each discrete voltage range.

8. A method for determining a null point voltage of a gyroscope that produces an output voltage related to an angular velocity to be measured by the gyroscope, comprising:

sampling the output voltage to obtain a plurality of sampled voltages;

assigning each sampled output voltage to a respective one of a plurality of bins, each bin representing a voltage range wherein each sampled output voltage is contained;

counting a number of sampled output voltages in each bin;

determining the bin with a highest count; and

selecting an associated voltage corresponding to a bin with the highest count.

9. The method of claim 2 further comprising reducing the count in each discrete voltage range at a predetermined time.

10. The method of claim 2 further comprising reducing the count in each discrete voltage range a number of voltage counts.

11. The method of claim 9 wherein the count in each discrete voltage range is divided by 2.

12. The method of claim 10 wherein the count in each discrete voltage range is divided by 2.

13. Apparatus for determining a null point voltage of a gyroscope that produces an output voltage related to an angular velocity to be measured by the gyroscope, comprising:

means for sampling the output voltage to obtain a plurality of sampled voltages; and

means for selecting an approximate mode of the plurality of sampled voltages as the null point voltage.

14. The apparatus of claim 13 further comprising means for counting the sampled voltages which fall within respective discrete voltage ranges; and

means for choosing a voltage associated with a discrete voltage range containing the highest count of sampled voltages.

15. The apparatus of claim 14 wherein each discrete voltage range has a low voltage and a high voltage.

16. The apparatus of claim 15 further comprising means for selecting a predetermined voltage from each discrete voltage range to be the associated voltage.

17. The apparatus of claim 15 further comprising means for determining said associated voltage for each discrete voltage range by adding the low voltage to the high voltage to obtain a voltage sum; and

means for dividing the voltage sum by a predetermined number.

18. The apparatus of claim 17 wherein the predetermined number is 2.

19. The apparatus of claim 15 wherein the associated voltage is an average of all of the sampled voltages within each discrete voltage range.

20. The apparatus of claim 16 further comprising:

means for assigning each sampled output voltage to a bin, each bin representing a voltage range within which a value of the sampled output voltage falls;

means for counting a number of sampled output voltages in each bin;

means for determining the approximate mode in each bin; and

means for selecting the associated voltage corresponding to the bin which contains the approximate mode.

21. The apparatus of claim 14 further comprising means for reducing the count in each discrete voltage range at a predetermined time.

22. The apparatus of claim 14 further comprising means for reducing the count in each discrete voltage range a number of voltages in the discrete voltage ranges.

23. The apparatus of claim 21 wherein the count in each discrete voltage range is divided by 2.

24. The apparatus of claim 22 wherein the count in each discrete voltage range is divided by 2.

25. A computer-readable media, which when executed by a processor, operates to determine a null point of a gyroscope comprising instructions for:

sampling the output voltage to obtain a plurality of sampled voltages; and

choosing an approximate mode of the plurality of sampled voltages as the null point voltage.

26. The computer-readable media of claim 25 further comprising instructions for:

counting the sampled voltages which fall within respective discrete voltage ranges and choosing a voltage associated with a discrete voltage range containing the highest count of sampled voltages.

27. The computer-readable media of claim 26 wherein each discrete voltage range has a low voltage and a high voltage.

28. The computer-readable media of claim 27 further comprising instructions for selecting a predetermined voltage from each discrete voltage range to be the associated voltage.

29. The computer-readable media of claim 28 wherein said instructions for selecting an associated voltage comprise instructions for adding the low voltage to the high voltage for each discrete voltage range to obtain a voltage sum, and for dividing the voltage sum by a predetermined number.

30. The computer-readable media of claim 29 wherein the predetermined number is 2.

31. The computer-readable media of claim 26 wherein said instructions for selecting an associated voltage comprise instructions for finding an average of all of the sampled voltages within each discrete voltage range.

32. A computer-readable media, which when executed by a processor, operates to determine a null point of a gyroscope comprising instructions for:

sampling the output voltage to obtain a plurality of sampled voltages;

assigning each sampled output voltage to a respective one of a plurality of bins, each bin representing a voltage range wherein each sampled output voltage is contained;

counting a number of sampled output voltages in each bin;

determining the bin with a highest count; and

selecting an associated voltage corresponding to a bin with the highest count.

33. The computer-readable media of claim 31 further comprising instructions for reducing the count in each discrete voltage range at a predetermined time.

34. The computer-readable media of claim 31 further comprising instructions for reducing the count in each discrete voltage range a number of voltages in the discrete voltage ranges.

35. The computer-readable media of claim 33 wherein the count in each discrete voltage range is divided by 2.

36. The computer-readable media of claim 34 wherein the count in each discrete voltage range is divided by 2.

37. A method for positioning an antenna during a satellite acquisition phase, comprising:

monitoring a voltage of a gyroscope related to an angular velocity measured by the gyroscope;

sampling the output voltage to obtain a plurality of sampled voltages;

choosing an approximate mode of the plurality of sampled voltages as the null point voltage;

moving the antenna through a 360 degree arc;

using the null point voltage of the gyroscope to verify that the antenna moved through a full 360 degree arc;

taking satellite energy measurements at discrete points throughout the full 360 degree arc; and

positioning the antenna towards the satellite based on a strongest satellite energy measurement.

38. A method for positioning an antenna used with a vehicle towards a pre-acquired satellite while the vehicle is changing directions, comprising:

monitoring a voltage of a gyroscope related to an angular velocity measured by the gyroscope;

sampling the output voltage to obtain a plurality of sampled voltages;

choosing an approximate mode of the plurality of sampled voltages as the null point voltage;

taking a first satellite energy measurement;

moving the antenna in a preselected direction;

using the null point voltage of the gyroscope to verify that the antenna moved to the preselected direction;

taking a second satellite energy measurement;

comparing the first satellite energy measurement to the second satellite energy measurement to see which is stronger; and

positioning the antenna based on the stronger energy measurement.

39. A system for positioning an antenna used with a vehicle, comprising:

a gyroscope for producing a voltage based on an angular velocity;

means for sampling the output voltage to obtain a plurality of sampled voltages;

means for choosing an approximate mode of the plurality of sampled voltages as a null point voltage;

means for subtracting the null point voltage from the sampled output voltage to obtain a voltage difference;

means for positioning an antenna based on the voltage difference; and

means for using the positioned antenna to determine the vehicle's position.

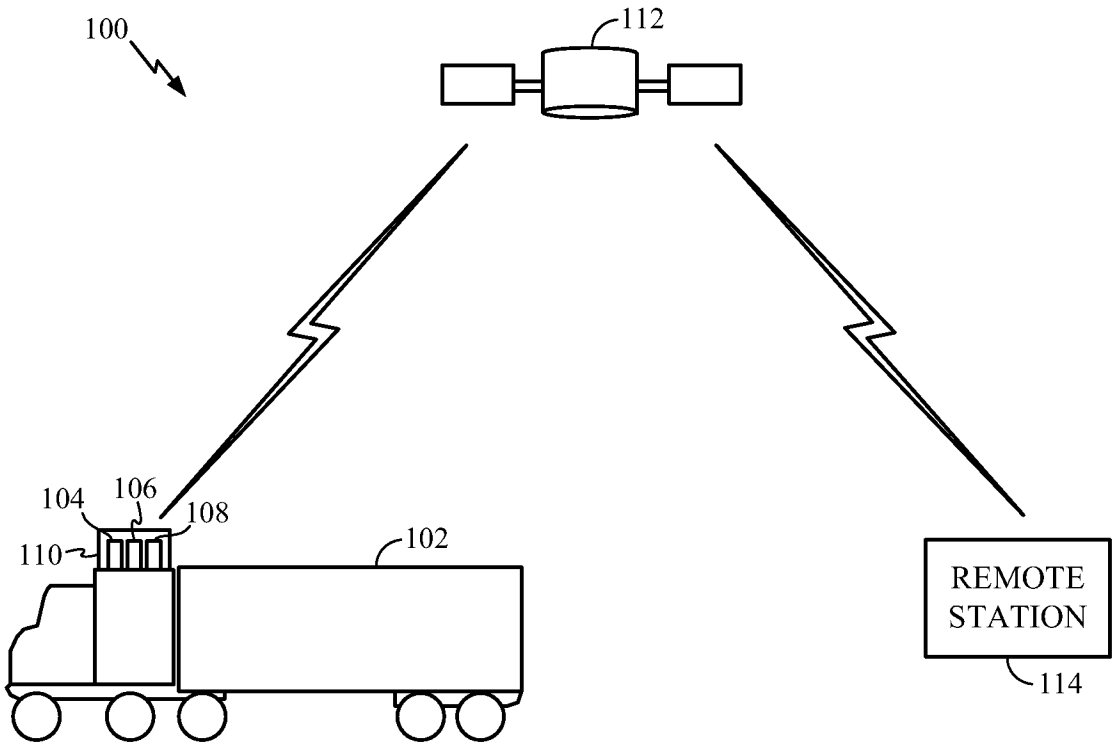

FIG. 1

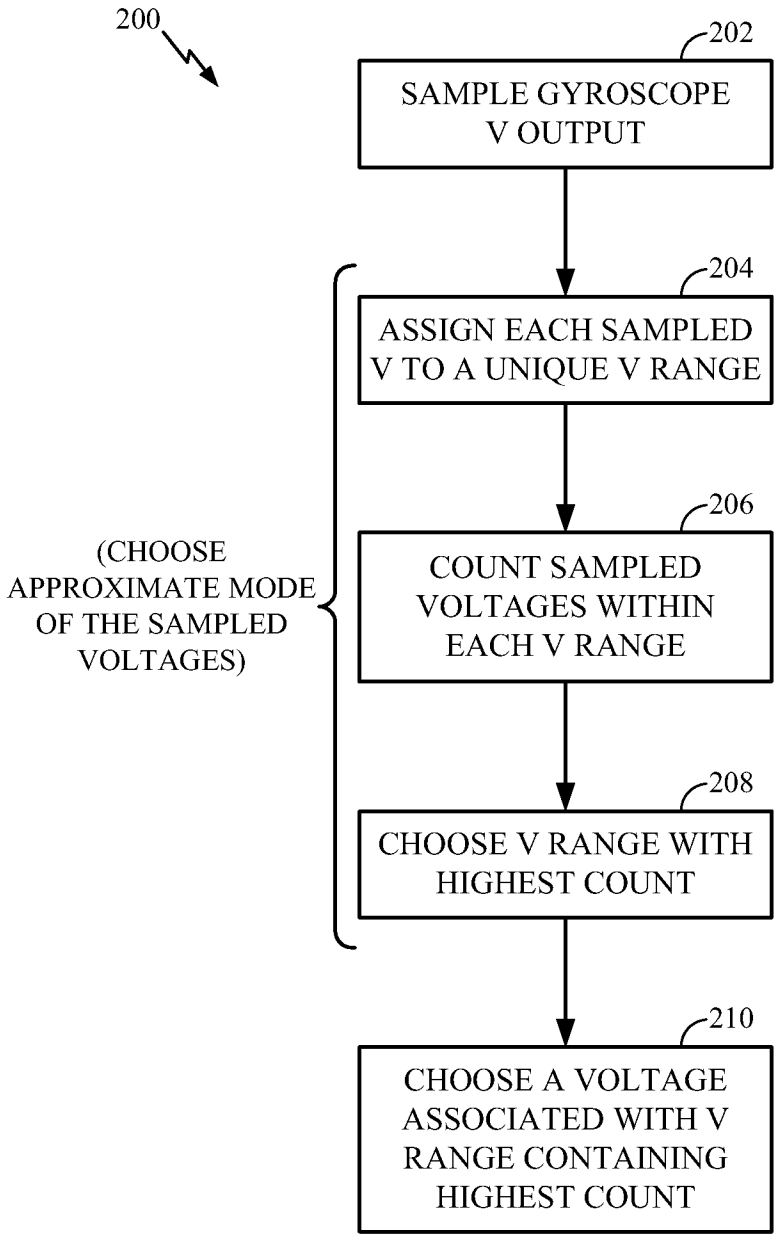
200
202
SAMPLE GYROSCOPE V OUTPUT
204
ASSIGN EACH SAMPLED V TO A UNIQUE V RANGE
206
COUNT SAMPLED VOLTAGES WITHIN EACH V RANGE
(CHOOSE APPROXIMATE MODE OF THE SAMPLED VOLTAGES)
208
CHOOSE V RANGE WITH HIGHEST COUNT
210
CHOOSE A VOLTAGE ASSOCIATED WITH V RANGE CONTAINING HIGHEST COUNT

FIG. 2

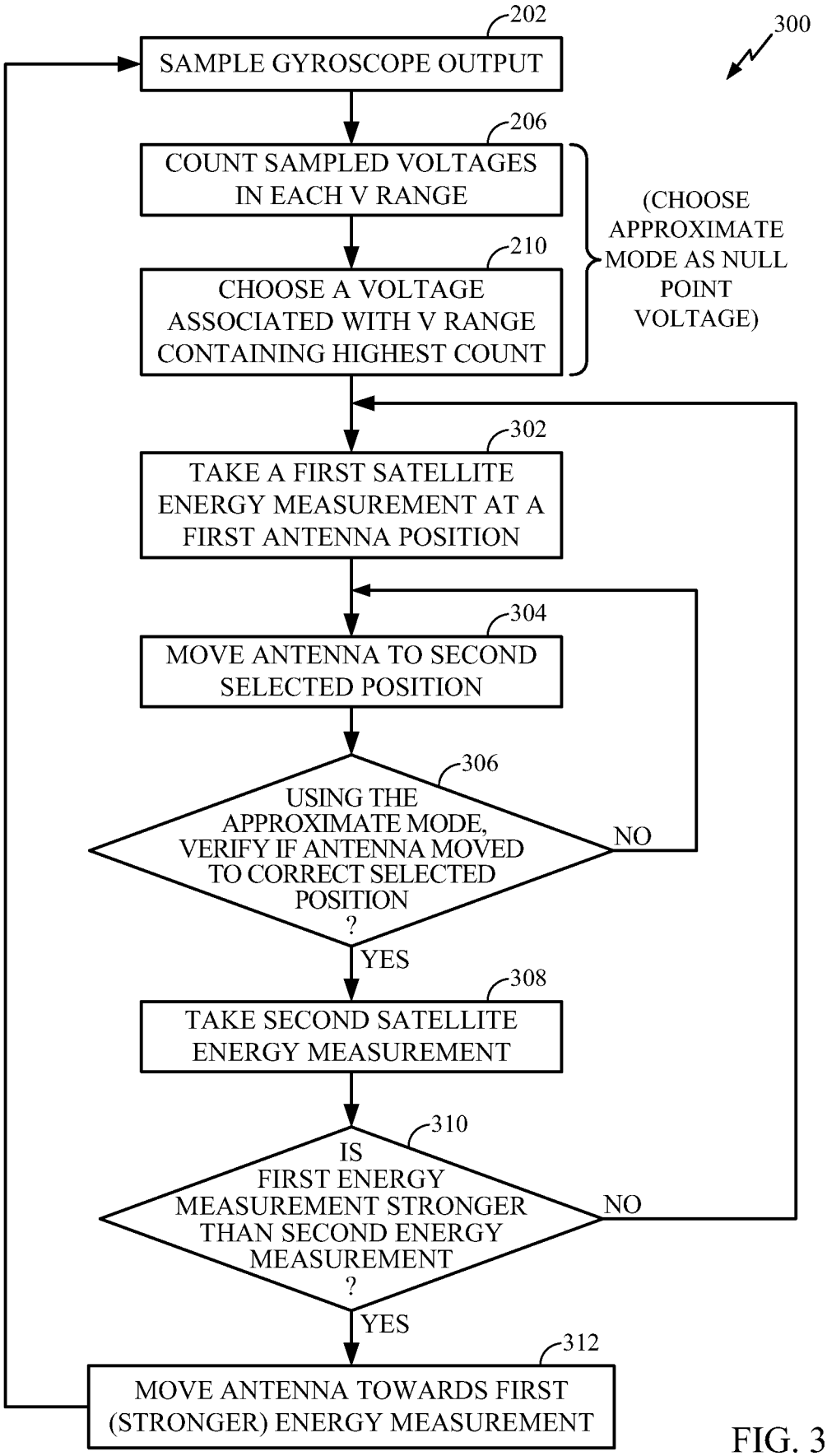
300
202
SAMPLE GYROSCOPE OUTPUT
206
COUNT SAMPLED VOLTAGES IN EACH V RANGE
210
CHOOSE A VOLTAGE ASSOCIATED WITH V RANGE CONTAINING HIGHEST COUNT
(CHOOSE APPROXIMATE MODE AS NULL POINT VOLTAGE)
302
TAKE A FIRST SATELLITE ENERGY MEASUREMENT AT A FIRST ANTENNA POSITION
304
MOVE ANTENNA TO SECOND SELECTED POSITION
306
USING THE APPROXIMATE MODE, VERIFY IF ANTENNA MOVED TO CORRECT SELECTED POSITION ?
NO
YES
308
TAKE SECOND SATELLITE ENERGY MEASUREMENT
310
IS FIRST ENERGY MEASUREMENT STRONGER THAN SECOND ENERGY MEASUREMENT ?
NO
YES
312
MOVE ANTENNA TOWARDS FIRST (STRONGER) ENERGY MEASUREMENT

FIG. 3

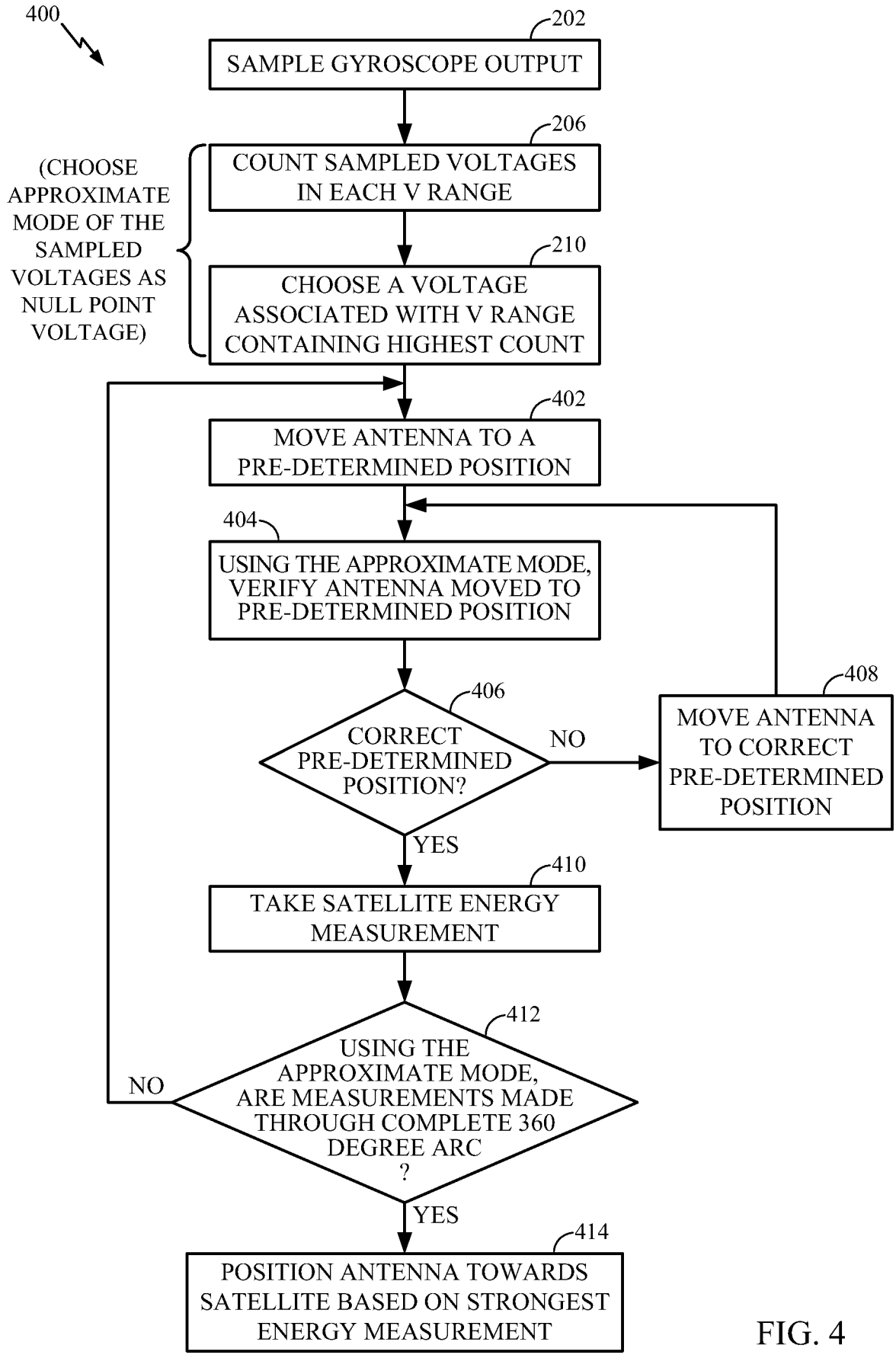
400
202
SAMPLE GYROSCOPE OUTPUT
206
COUNT SAMPLED VOLTAGES IN EACH V RANGE
(CHOOSE APPROXIMATE MODE OF THE SAMPLED VOLTAGES AS NULL POINT VOLTAGE)
210
CHOOSE A VOLTAGE ASSOCIATED WITH V RANGE CONTAINING HIGHEST COUNT
402
MOVE ANTENNA TO A PRE-DETERMINED POSITION
404
USING THE APPROXIMATE MODE, VERIFY ANTENNA MOVED TO PRE-DETERMINED POSITION
406
CORRECT PRE-DETERMINED POSITION?
NO
408
MOVE ANTENNA TO CORRECT PRE-DETERMINED POSITION
YES
410
TAKE SATELLITE ENERGY MEASUREMENT
412
USING THE APPROXIMATE MODE, ARE MEASUREMENTS MADE THROUGH COMPLETE 360 DEGREE ARC ?
NO
YES
414
POSITION ANTENNA TOWARDS SATELLITE BASED ON STRONGEST ENERGY MEASUREMENT

FIG. 4

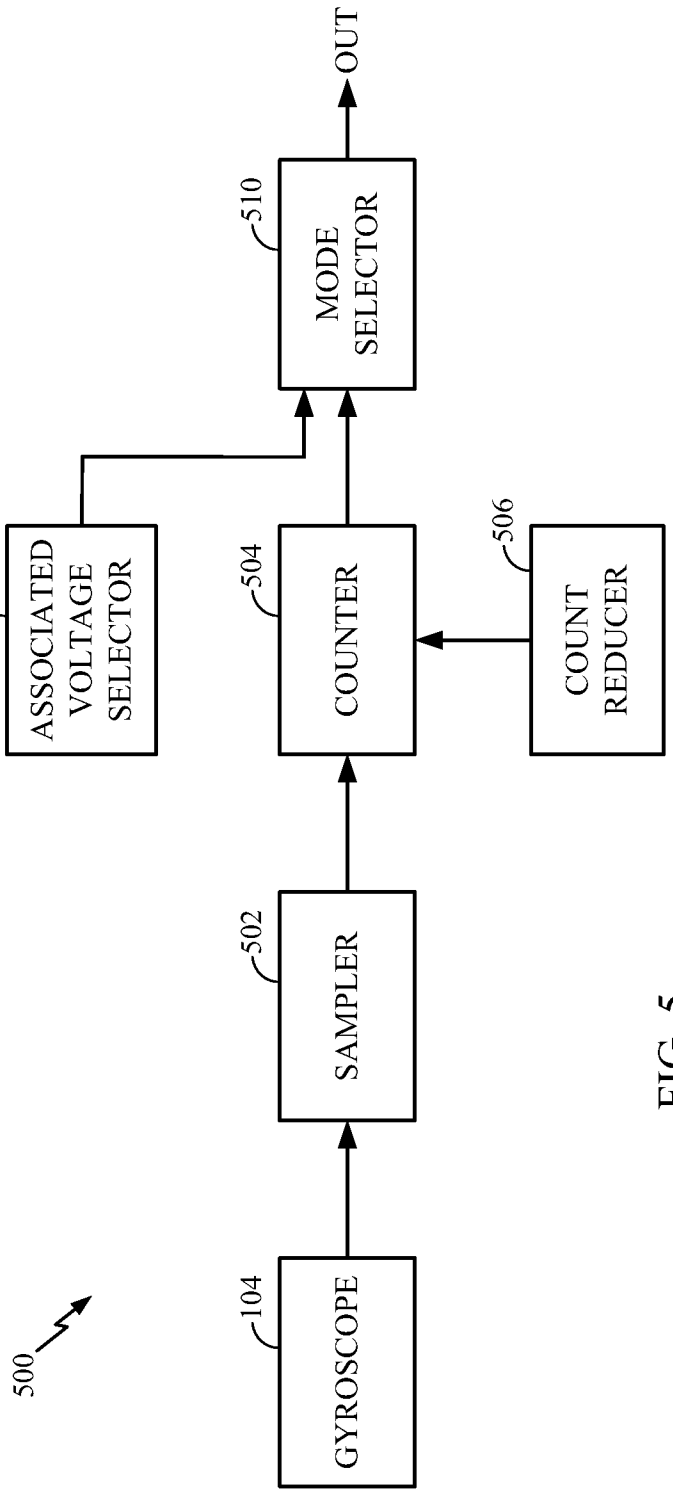
500
104
GYROSCOPE
502
SAMPLER
504
COUNTER
506
COUNT REDUCER
508
ASSOCIATED VOLTAGE SELECTOR
510
MODE SELECTOR
OUT

FIG. 5

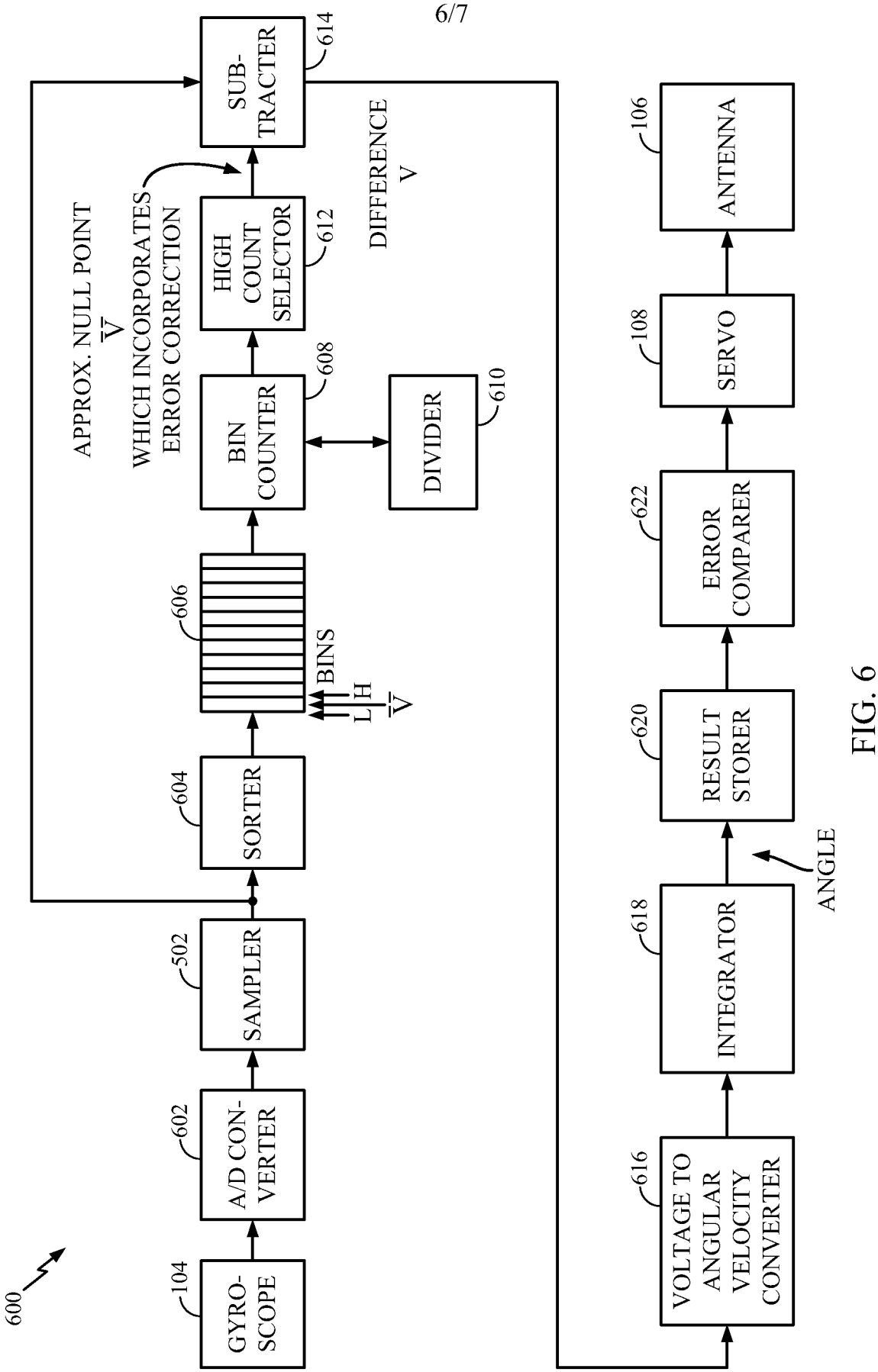
600
GYRO-SCOPE
104
A/D CON-VERTER
602
SAMPLER
502
SORTER
604
BINS
606
L H
BIN COUNTER
608
DIVIDER
610
HIGH COUNT SELECTOR
612
SUB-TRACTER
614
APPROX. NULL POINT
WHICH INCORPORATES ERROR CORRECTION
DIFFERENCE
VOLTAGE TO ANGULAR VELOCITY CONVERTER
616
INTEGRATOR
618
RESULT STORER
620
ERROR COMPARER
622
SERVO
108
ANTENNA
106
ANGLE

FIG. 6

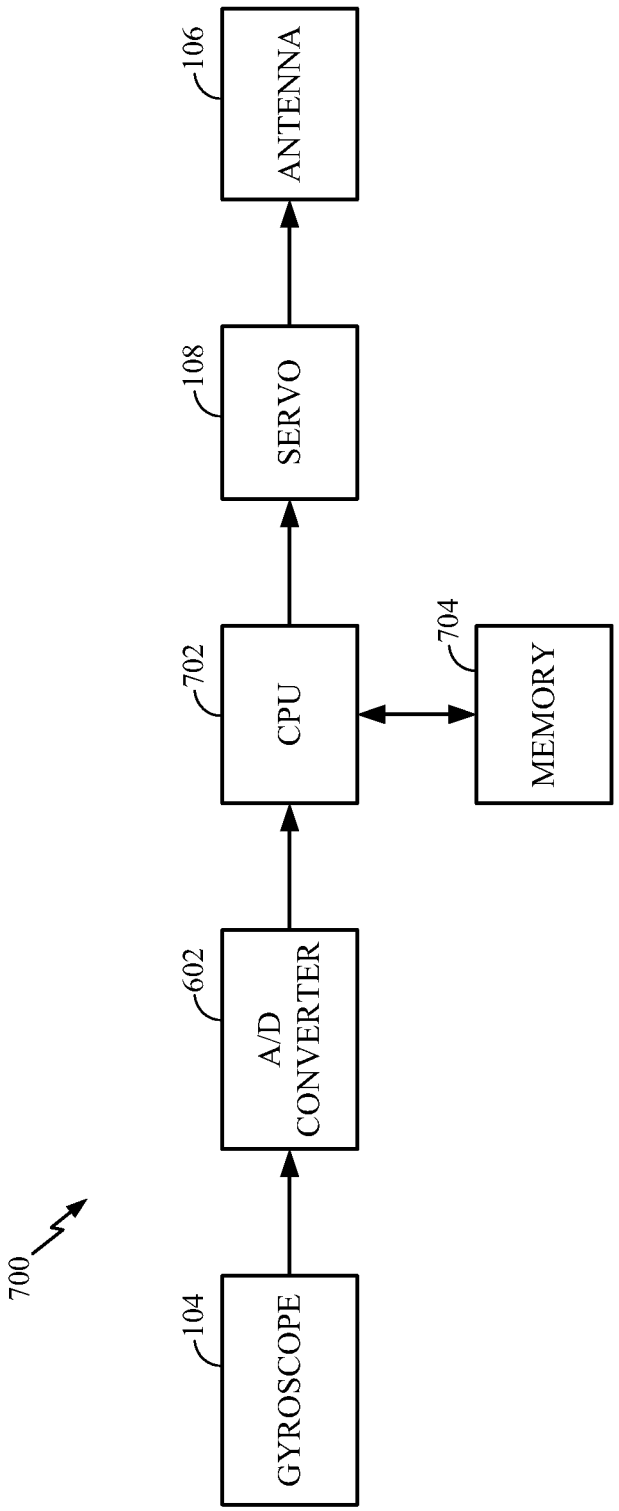
700
104
GYROSCOPE
602
A/D CONVERTER
702
CPU
704
MEMORY
108
SERVO
106
ANTENNA

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/059311

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01Q1/12 G01C25/00

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 H01Q

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 practical, search terms used)
EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	EP 0 809 322 A (TOYOTA MOTOR CO LTD [JP]) 26 November 1997 (1997-11-26)	37,38
X	claim 1	39
X	US 6 972 724 B1 (TIAN BIN [US] ET AL) 6 December 2005 (2005-12-06)	37,38
X	column 2, lines 25-40 - column 12, lines 58-67	39
X	US 4 470 124 A (TAGAMI KATSUTOSHI [JP] ET AL) 4 September 1984 (1984-09-04) column 6, lines 21-49	1-39
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] 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 document 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
24 July 2008	04/08/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Dragomir, Adrian

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/059311

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	columns 3-5; claim 1	39
X	EP 0 432 647 A (TOYODA CHUO KENKYUSHO KK [JP]) 19 June 1991 (1991-06-19)	37,38
X	columns 3-5; claims 1,2	39
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X	columns 4,5; claim 1	39

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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