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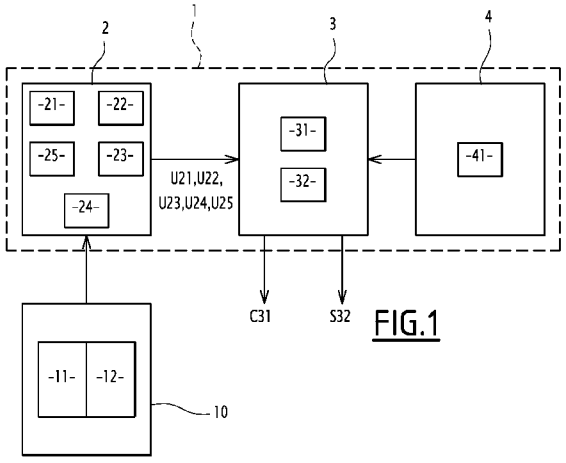


FIG.1

(57) Abstract: The invention relates to a system (1) for shifting at least one analogical output signal (C31, S32; C31; S32) of a sensor device (2+3), comprising a sensor (2) including at least two detection cells (21, 22, 23, 24, 25) adapted to equip a mechanical device (10) and to deliver voltage signals (U21, U22, U23, U24, U25) depending on behaviour of the mechanical device (10), and an electronic circuit (3) processing the voltage signals (U21- U25) to deliver the at least one output signal of the sensor device (2+3) depending on behaviour of the mechanical device (10). The circuit (3) comprises at least a first part (31) including at least one passive analogical component with a variable parameter and processing the voltage signals (U21-U25) to deliver a first sinusoidal signal (C31), and a second part (32) including at least one passive analogical component with a variable parameter and processing the voltage signals (U21-U25) to deliver a second sinusoidal signal (S32). The system (1) also comprises control means (4) for controlling the variable parameters of the passive analogical components, a variation of at least one of the variable parameters shifting the at least one output signal of the sensor device (2+3). This at least one shifted output signal of the sensor device (2+3) includes the first sinusoidal signal and/or the second sinusoidal signal. The invention also relates to a sensor-bearing unit including a bearing and such a system (1). The invention also concerns a method for shifting at least one analogical output signal of a sensor device (2+3).

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A SYSTEM FOR SHIFTING AN ANALOGICAL OUTPUT SIGNAL OF A SENSOR DEVICE, A SENSOR-BEARING UNIT AND A SHIFTING METHOD

TECHNICAL FIELD OF THE INVENTION

The invention concerns a system and a method for shifting at least one analogical output signal of a sensor device. The invention also concerns a sensor-bearing unit including a bearing and such a system.

BACKGROUND OF THE INVENTION

It is known to equip a mechanical device, such as a motor including a rotor and a stator, with a sensor-bearing unit for tracking the rotation of the rotor relative to the stator. Other mechanical devices including a mobile part and a stationary part may be equipped with such a sensor device, for example power steering, alternator and rack rails devices. Depending on the mechanical device, the mobile part may move in rotation or in translation. Thus, the sensor device may include a rotation angle sensor or a linear sensor.

In other words, each mechanical device is equipped with a dedicated sensor device, implying a specific indexation to provide effective measurements.

Some customers using sensor-bearing units do not have a lot of experience and knowledge on the motor control strategies and therefore use off-the-shelve solutions. These solutions often only accept a very precise indexation of the sensor-bearing output signals with the rotor magnetic field. Typically, an error of only ±8 degrees may be accepted between the zero-index of the output signals and the zero-index of the rotor if this error may be adjusted by a controller, and an error of only ±0.5 degrees may be accepted in case there is no adjustment in a controller.

Mechanically, the zero-index can be set in two ways: pre-indexing the rotor with the shaft (achieved by the motor manufacturer) and/or pre-indexing the shaft with the sensor (achieved by motor manufacturer or sensor manufacturer). These methods are difficult and costly to implement since they involve a precise mechanical indexation.

For instance, it is known to mount a sensor-bearing unit with a degree of freedom on a shaft, allowing the sensor to rotate in order to mechanically shift the output signals with respect to the rotor. A rotation of the sensor up to 180 degrees around the rotor may be necessary to provide correct shift. Such a method is difficult to implement and requires specific tooling for precise indexation of mechanical angular offset.

WO-A-2010/082086 describes a method and a device for sensing an absolute rotation angle of an electric energy assisted steering, comprising a rotor mobile around a

rotation axis and through several revolutions. The sensing device is connected to an electronic control unit (ECU) having a signal processor, a converter, a calculating processor and an integrating unit. ECU adjusts the offset and the gain of output signal of the sensing device.

SUMMARY OF THE INVENTION

The aim of the invention is to provide simple system and method for shifting at least one of the analogical output signals of a sensor device.

To this end, the invention concerns a system for shifting at least one analogical output signal of a sensor device, comprising a sensor including at least two detection cells adapted to equip a mechanical device and to deliver voltage signals depending on behaviour of the mechanical device, and an electronic circuit processing the voltage signals to deliver the at least one analogical output signal of the sensor device depending on behaviour of the mechanical device. The electronic circuit comprises at least: a first part including at least one passive analogical component having a variable parameter, the first part processing the voltage signals to deliver a first sinusoidal signal, and a second part including at least one passive analogical component having a variable parameter, the second part processing the voltage signals to deliver a second sinusoidal signal. The system also comprises control means for controlling the variable parameters of the passive analogical components, a variation of at least one of the variable parameters shifting at least one analogical output signal of the sensor device. This at least one shifted analogical output signal of the sensor device includes the first sinusoidal signal and/or the second sinusoidal signal.

Thanks to the invention, electrical angular offset may be shifted without needing a precise indexation of mechanical angular offset. Moreover, no intervention of the user inside the software of a complex controller is needed. In certain cases, an existing sensor device can be modified by replacement of a passive component having a fixed parameter with another passive component having a variable parameter, without addition of additional passive components in the circuit. With the simple, cheap and efficient system and method according to the invention, a maximum realizable shift of almost 7 degrees can be obtained, as detailed hereafter.

According to further aspects of the invention which are advantageous but not compulsory, such a system may incorporate one or several of the following features:

- The detection cells of the sensor and at least the first part and the second part of the electronic circuit are located together in a housing of the sensor device.

- The electronic circuit delivers two shifted analogical output signals, which are the first sinusoidal signal and the second sinusoidal signal.

- Each of the first part and second part of the electronic circuit includes only one passive analogical component having a variable parameter.

- The control means modify the variable parameters of the passive analogical components simultaneously.

- The control means modify the two variable parameters of the two passive analogical components simultaneously in a reversed way.

- The first sinusoidal signal is a cosine signal, the second sinusoidal signal is a sine signal, and an arctangent function applied to a division of the sine signal by the cosine signal corresponds to a rotation angle of a rotating part relative to a stationary part of the mechanical device.

- The control means comprise at least one potentiometer associated with at least one of the passive analogical components and adapted to selectively modify the variable parameter of this passive analogical component.

- The control means comprise an emitter adapted to selectively act on at least one of the passive analogical components and to modify the variable parameter of this passive analogical component.

- The emitter is a laser emitter adapted to selectively emit a laser ray on at least one of the passive analogical components and to modify the variable parameter of this passive analogical component.

- At least one of the passive analogical components is a resistor component and its variable parameter is a resistance value.

- At least one of the passive analogical components is an inductor component and its variable parameter is an inductance value.

- The sensor comprises at least three detection cells, preferably five detection cells.

The invention also concerns a sensor-bearing unit including a bearing and a system as mentioned here-above, wherein the sensor of the system and the bearing equip a stationary part and a rotating part of the mechanical device. Preferably, an outer ring of the bearing and the detection cells of the sensor are mounted on the outer stationary part of the mechanical device, while an inner ring of the bearing and an encoder associated with the detection cells are mounted on the inner rotating part of the mechanical device. Alternatively, an inner ring of the bearing and the detection cells of the sensor are mounted on the inner stationary part of the mechanical device, while an outer ring of the bearing and an encoder associated with the detection cells are mounted on the outer rotating part of the mechanical device.

The invention also concerns a method for shifting at least one analogical output signal of a sensor device, which comprises a sensor including at least two detection cells adapted to equip a mechanical device, and an electronic circuit delivering the at least one analogical output signal of the sensor device depending on behaviour of the mechanical device. The method includes at least the following steps:

- the detection cells deliver voltage signals depending on behaviour of the mechanical device;
- a first part of the electronic circuit, including at least one passive analogical component having a variable parameter, processes the voltage signals to deliver a first sinusoidal signal;
- a second part of the electronic circuit, including at least one passive analogical component having a variable parameter, processes the voltage signals to deliver a second sinusoidal signal; and
- control means, forming a shifting system together with the sensor device, control the variable parameters of the passive analogical components, a variation of at least one of the variable parameters shifting at least one analogical output signal of the sensor device, wherein this at least one shifted analogical output signal includes the first sinusoidal signal and/or the second sinusoidal signal.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained in correspondence with the annexed figures, and as an illustrative example, without restricting the object of the invention. In the annexed figures:

- figure 1 is a schematic representation of a system according to the invention, including a sensor associated with a mechanical device, an electronic circuit and control means;
- figure 2 is a schematic representation of the mechanical device of figure 1, of the motor type, including a rotor and a stator, equipped with detection cells belonging to the sensor;
- figure 3 is an electronic diagram of a cosine part belonging to the electronic circuit of figure 1 and including five primary resistor components;
- figure 4 is an electronic diagram of a sine part belonging to the electronic circuit of figure 1 and including five primary resistor components;
- figure 5 is a graph corresponding to the cosine part of figure 3, with variations of parameters associated with the five primary resistor components;

- figure 6 is a graph showing a certain range of figure 5, corresponding to the cosine part of the electronic circuit, at a larger scale;
- figure 7 is a graph similar to figure 6, corresponding to the sine part of the electronic circuit;
- figure 8 is a graph showing an angle shift accomplished with a variation of the parameter of one primary resistor component of each cosine part and sine part and with a variation of parameters associated with all primary resistor components;
- figure 9 is a graph showing a shift angle error for both cases shown of figure 8;
- figure 10 is an electronic diagram similar to figure 4, for a sine part belonging to a system according to a second embodiment of the invention and including three primary resistor components; and
- figure 11 is an electronic diagram similar to figure 4, for a sine part belonging to a system according to a third embodiment of the invention and including two primary resistor components.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

The system 1 shown on figure 1 may be implemented for shifting at least one analogical output signal C31 and/or S32 of a sensor device 2+3.

The sensor device 2+3 comprises a sensor 2 and an electronic circuit 3. Sensor 2 cooperates with a mechanical device 10, while electronic circuit 3 cooperates with control means 4, as detailed hereafter. Sensor 2 includes five detection cells 21, 22, 23, 24 and 25, adapted to equip the mechanical device 10 and to deliver respective voltage signals U21, U22, U23, U24 and U25 depending on the behaviour of the mechanical device 10. Sensor 2 is an analogical sensor measuring continuous information and cells 21-25 are analogical detection cells delivering analogical voltage signals U21-U25. The electronic circuit 3 processes the voltage signals U21-U25 to deliver the analogical output signals C31 and S32 of the sensor device 2+3, depending on the behaviour of mechanical device 10. Control means 4 are adapted to selectively act on the electronic circuit 3 to shift at least one of the analogical output signals C31 and S32 of the sensor device 2+3, preferably both analogical output signals C31 and S32, in order to adjust its zero-index relative to mechanical device 10.

As shown on figure 2, the mechanical device 10 may be of the rotating type and be equipped with an absolute rotation angle sensor 2, according to a configuration described in document WO-A-2010/082086, which is incorporated herein by reference.

This mechanical device 10 comprises a stationary part 11 and a rotating part 12 centered on a central axis X10. Stationary part 11 may include a housing and a stator and

is represented by a circle on figure 2 for simplification purpose. Rotating part 12 may include a rotor belonging to an electric energy assisted steering unit (EPAS). Rotating part 12 is shaped as an annular ring with symmetry of revolution around axis X10.

Sensor 2 can be either integrated into the motor or located close to the motor of the EPAS. Sensor 2 comprises the five detection cells 21-25, such as Hall-effect cells, and an encoder 13, such as a magnet. Alternatively, any suitable detection technology may be used for cells 21-25 and encoder 13, such as optical or induction technologies.

Cells 21-25 are positioned on stationary part 11, at a detection distance from encoder 13 which is fast in rotation around axis 10 with rotating part 12. Encoder 13 forms an annular ring around axis X10 and comprises a pair of magnetic poles 14 and 15, more precisely a north (N) pole 14 and a south (S) pole 15. Encoder 13 extends along the whole circumference of axis X10, with N pole 14 and S pole 15 disposed oppositely around axis X10. Preferably, encoder 13 comprises a higher number of pairs of poles, for example sixty-four pairs of poles 14 and 15. Cells 21-25 are adapted to sense N pole(s) 14 and S pole(s) 15 when rotating part 12 rotates. Thus, each cell 21-25 delivers a voltage signal U21-U25 depending on the rotation of rotating part 12 around axis X10 relative to stationary part 11.

More precisely, three first cells 21, 22 and 23 form together a first sensing group, while two second cells 24 and 25 form together a second sensing group, as described in document WO-A-2010/082086. First cells 21, 22 and 23 are angularly evenly distributed around axis X10, in other words are separated two by two by a mechanical angle of 120 degrees. Second cells 24 and 25 are angularly separated by a mechanical angle of 90 degrees (modulo 180 degrees).

First cells 21, 22 and 23 are adapted to output first voltage signals, respectively U21, U22 or U23, which are representative of the current absolute angular position of rotating part around axis X10, such as disclosed in WO-A-2007/077389, which is also incorporated herein by reference. Each cell 21, 22 and 23 is supplied with a constant voltage and generates an output voltage which varies according to the magnetic field generated by the encoder 13 and sensed by the cell.

Second cells 24 and 25 are mutually positioned so as to output respective second voltage signals, respectively U24 and U25, having a predetermined phase shift of 90 degrees. Since second cells 24 and 25 output sine-wave signals and since they are separated by a shift angle of 90 degrees (modulo 180 degrees), they output respective second signals with a phase shift of 90 degrees. Hence, when second cell 24 outputs a sine signal, second cell 25 outputs a cosine signal. These second signal, sine and cosine,

are representative of the revolution in which is positioned rotating part 12, hence the rotor of the mechanical system 10.

Alternatively, detection cells 21-25 may be regularly distributed at 0 degrees, 72 degrees, 144 degrees, 216 degrees and 288 degrees around axis X10. In this case, cells 21-25 may not be divided into a first sensing group and a second sensing group.

As shown on figures 1, 3 and 4, the electronic circuit 3 comprises at least a first part 31 and a second part 32 both receiving voltage signals U21-U25 from cells 21-25. Circuit 3 also comprises several electronic devices and components, such as power supply means, signal filters, counter, memory, wires and connectors, not shown for simplification purpose. Each device or component may be analogical and/or numerical. Preferably, electronic circuit 3 includes analogical devices and components, transmitting analogical signals.

In reference to the mechanical assembly including sensor 2 and mechanical device 10 on figure 2, the electronic circuit 3 may be configured in a way close or similar to document WO-A-2010/082086, except the differences detailed here-after.

Within circuit 3, first part 31 delivers a cosine signal C31, while second part 32 delivers a sine signal S32. In other words, they may be designated as cosine part 31 and sine part 32, or else interpolating parts 31 and 32 since they are adapted to integrate the voltage signals U21-U25 from detection cells 21-25. Preferably, filters are inserted between cells 21-25 and interpolating parts 31 and 32 in order to clean voltage signals U21-U25. Thus, electronic circuit 3 is adapted to integrate the voltage signals U21-U25 from detection cells 21-25.

Cosine part 31 includes five primary resistors R61, R62, R63, R64 and R65, each receiving one of the voltage signals, respectively U21, U22, U23, U24 and U25. Cosine part 31 also includes an operational amplifier A60, connectors B61 and B62, and secondary resistors R66, R67 and R68. Resistor R67 receives a voltage U1 whose value is superior to +3,3 volts, for instance equal to +5 volts. Resistor R68 is connected to electrical ground, in other words receives a voltage U0 whose value is equal to zero volts. Resistors R61 and R65 are connected to connector B61, while resistors R62, R63 and R64 are connected to connector B62. Resistors R61 to R68 are passive analogical components. Resistor R64 has a variable resistance parameter P64, while each one of the other resistors of cosine part 31 has its own fixed resistance parameter. A variation of parameter P64 modifies analogical cosine signal C31.

Sine part 32 includes components A70, B71, B72 and R71 to R78, similar to the components of cosine part 31 having the same references minus 10. Components A70, B71, B72, R71 to R78 respectively works in the same way as components A60, B61, B62,

R61 to R68. Sine part 32 includes five primary resistors R71, R72, R73, R74 and R75, each receiving one of the voltage signals, respectively U21, U22, U23, U24 and U25. Resistors R61 and R62 are connected to connector B72, while resistors R63, R64 and R65 are connected to connector B71. Resistors R71 to R78 are passive analogical components. Resistor R73 has a variable resistance parameter P73, while each one of the other resistors of sine part 32 has its own fixed resistance parameter. A variation of parameter P73 modifies analogical sine signal S32.

In practice, electronic circuit 3 is adapted to deliver analogical cosine signal C31 and analogical sine signal S32 to another electronic device located outside sensor device 2+3. In other words, signals C31 and S32 are output analogical signals of sensor device 2+3. Advantageously, an arctangent function applied to a division of sine signal S32 by cosine signal C31 corresponds to a rotation angle θ of rotating part 12 relative to stationary part 11 of mechanical device 10.

Preferably, detection cells 21-25 of sensor 2 and at least the first part 31 and second part 32 of the electronic circuit 3 are located together in a housing of the sensor device 2+3. Thus, sensor device 2+3 is compact and simple to mount on mechanical device 10. Also preferably, control means 4 may be included in the same housing.

According to the invention, control means 4 are adapted to shift selectively at least one of the analogical output signals C31 and S32 in a simple way, without needing a specific and complex electronic controller unit. Preferably, control means 4 are adapted to shift both analogical output signals C31 and S32 simultaneously, as detailed here-after. In other words, system 1 and more precisely control means 4 are adapted to shift selectively at least one analogical output signal of sensor device 2+3, this at least one shifted analogical output signal selectively including first output signal C31 and/or second output signal S32. In certain cases, only one of the two signals C31 and S32 may be shifted. Preferably both output signals C31 and S32 are shifted.

As shown on figure 1, control means 4 include at least one device 41, such as a potentiometer, an emitter or an actuator, adapted to act on variable resistors R64 and/or R73 to selectively modify resistance parameters P64 and/or P73. Device 41 may be a potentiometer associated with at least one of the resistors R64 and/or R73 and adapted to selectively modify the variable parameter(s) P64 and/or P73 of this resistor(s). Device 41 may be an emitter, preferably a heat energy emitter, such as a laser emitter adapted to selectively emit a laser ray on at least one of the resistors R64 and/or R73 and to modify the variable parameter(s) P64 and/or P73 of this resistor(s). Preferably, control means 4 are adapted to modify the variable resistance parameters P64 and P73 of the resistors R64 and R73 simultaneously.

Graphs of figures 5 to 9 depict the operating principle of the invention.

On figures 5, 6 and 7, shift angle θs corresponding to signals C31 and S32 is represented in degrees on the abscissa axis, while resistance values in kiloOhm (kΩ) are represented on the ordinate axis. More precisely, the ordinate axis of figures 5 and 6 correspond to resistance values of primary resistors R61-R65 of cosine part 31, while the ordinate axis of figure 7 corresponds to resistance values of primary resistors R71-R75 of sine part 32.

On figure 5, shifting is simulated on the basis on modified design of cosine part 31 within electronic circuit 3. More precisely, for each value of shift angle θs on a shift interval extending from 0 to 360 degrees, the corresponding resistance values primary resistors R61-R65 of cosine part 31 are determined. In standard design, used shift angle θs is 45 degrees since this gives the same coefficients and thus resistance values for cosine part 31 and sine part 32. According to simulation, shift angle θs extends from 0 to 360 degrees to cover the entire shift interval. Respective resistance values of secondary resistors R66, R67 and R68 are fixed, by example 2.05 kΩ for resistor R66 and 4.12 kΩ for both resistors R67 and R68. Then, respective resistance values of primary resistors R61 to R65 are modified. Each 36 degrees a peak appears where the value of a corresponding primary resistor R61 to R65 becomes infinite.

The same method may be applied to sine part 32, with shifting simulated on the basis of modified design of sine part 32 within electronic circuit 3. In practice, simulation may be applied simultaneously to cosine part 31 and sine part 32.

As shown on figures 6 and 7, a shift interval has to be chosen such that there are no peaks in the varying resistance values, for both cosine part 31 and sine part 32. Indeed, peaks are highly nonlinear and a variable resistor having such a profile is hard or impossible to find. Since there are two signals C31 and S32, the maximum possible angle shift interval is thus 18 degrees.

The chosen shift interval, without peaks in the varying resistance values, is comprised between 36 and 54 degrees. Peaks are present for these boundary values of 36 and 54 degrees. This interval corresponds to variation of parameter P64 of resistor R64 and parameter P73 of resistor R73, while other primary resistors R61, R62, R63, R64, R71, R72, R74 and R75 of both parts 31 and 32 keep constant resistance values corresponding to average values over the shift interval. For example, respective resistance values of resistors R61, R62, R63, R64, R71, R72, R74 and R75 are 7.3 kΩ, 32.4 kΩ, 5.32 kΩ, 11.3 kΩ, 7.32 kΩ, 11.3 kΩ, 32.4 kΩ and 5.76 kΩ. In practice, parameters P64 and P73 change significantly and in a reversed way. Thus, preferably,

control means 4 are adapted to modify the two variable parameters P64 and P73 simultaneously in a reversed way.

If the chosen shift interval was different from 36 to 54 degrees, the primary resistors having a variable parameter would be different from resistors R64 and R73.

On figure 8, intended angle shift θi corresponding to signals C31 and S32 is represented on the abscissa axis, while realized angle shift θr is represented on the ordinate axis, each in degrees. The bold curve corresponds to a variation of all primary resistance values, as shown on figure 5. This bold curve is not completely straight because cosine part 31 and sine part 32 each comprise a limited number of resistors, but an ideal shift of signals C31 and S32 is almost accomplished. The thin curve corresponds to a variation of parameters P64 and P73 while other primary resistance values remain fixed. As expected, while only two variable parameters P64 and P73 are modified, the output signals C31 and S32 shift with a certain angle θr, but not exactly the ideal shift angle θ. Nevertheless, a variation of only two variable parameters P64 and P73 thanks to control means 4 is far easier to realize than a variation of all resistance values. Beside, the result is fully satisfactory in the acceptable error range.

On figure 9, intended angle shift θi is represented on the abscissa axis, while angle shift error Δθ is represented on the ordinate axis, each in degrees. The angle shift error Δθ corresponds to the difference, in absolute value, between intended angle shift θi and realized angle shift θr shown on figure 8. The bold curve corresponds to variation of all primary resistance values, with a maximum error Δθ of 0,34 degrees. The thin curve corresponds to variation of parameters P64 and P73, with a maximum error Δθ of 0,62 degrees, which is acceptable.

As shown on figure 9, a maximum realizable shift θmax of approximately 7 degrees can be obtained in a simple manner thanks to system 1. In the present case, this value of 7 degrees is related to the practical maximum resistance values P64 and P73, considering that the ideal resistance values would become infinite. System 1 is not compulsorily connected to an electronic control unit (ECU). Even if system 1 is connected to such an ECU, shifting of analogical output signal(s) C31 and/or S32 may be accomplished by controls means 4 of system 1, without complex operations of the ECU.

As shown on figures 10 and 11, sensor 2 may include three or even two detection cells, depending on the accuracy and response time required for sensor device 2+3.

A second embodiment of a sine part 132 is shown on figure 10, while a third embodiment of a sine part 232 is shown on figure 11. Other constitutive elements of system 1 including sine part 132 or 232 are not shown on figures 10 and 11 for simplification purpose.

In these embodiments, elements A32 and B71 working in the same way as in sine part 32 of the first embodiment have the same references, while resistors working in the same way but possibly having resistance values different from sine part 32 have references increased by 100 for sine part 132 and by 200 for sine part 232. These are resistors R171, R172, R173, R176, R177, R178, R271, R272, R276, R277 and R278. Sine part 132 processes the voltage signals U21, U22 and U23 to deliver sine signal S132, while sine part 232 processes the voltage signals U21 and U22 to deliver sine signal S232. According to the invention, on a chosen shift interval, resistor R172 of sine part 132 has a variable resistance parameter P172, while resistor R272 of sine part 232 has a variable resistance parameter P272. For a given number of detection cells and voltage signals, cosine part is designed in a way similar to sine part 132 or 232.

According to the invention, sensor 2 comprises at least two detection cells. In the simplest configuration corresponding to figure 11, sensor 2 includes only two detection cells spaced apart angularly and delivering two voltage signals U21 and U22. A first cell is enough to determine whether one full revolution has been made, while a second cell is needed in order to determine the direction of revolution of the mobile part 12 relative to stationary part 11 of mechanical device 10.

Other non-shown embodiments of system 1 can be implemented without leaving the scope of the invention. Particularly, system 1 may comprise different configuration of sensor device 2+3 or control means 4. Moreover, system 1 may be adapted to different mechanical device 10. Sensor 2 may equip any mechanical device where a specific behaviour, as a movement of rotation or translation, is measured. For example, sensor 2 may equip an electric vehicle, a starter alternator or an in-wheel motor for fork lift truck.

According to another possible embodiment of the invention, system 1 may comprise a control circuit 3 adapted to deliver more than two analogical output signals of a sensor device 2+3. In this case, control means 4 are also adapted to shift at least one shifted analogical output signal of sensor device 2+3.

According to another non-shown embodiment, mechanical device 10 includes a mobile part 12 moving in translation relative to stationary part 11, such as in a rail rack device. In this case, system 1 includes a linear sensor device 2+3. Control means 4 of system 1 are adapted to shift the analogical output signal of the sensor device 2+3, in order to adjust its zero-index relative to mechanical device 10.

According to another non-shown embodiment, electronic circuit 3 may include other passive analogical components in place of primary resistors. For instance, at least one of the passive analogical components is an inductor component and its variable parameter is an inductance value.

Whatever the embodiment, the shifting system 1 comprises a sensor 2 including at least two detection cells adapted to equip a mechanical system 10 and to deliver voltage signals depending on behaviour of this mechanical device 10. The shifting system 1 also comprises an electronic circuit 3 comprising at least a first part 31 including at least one passive analogical component R64 having a variable parameter P64 and a second part 32 including at least one passive analogical component R73 having a variable parameter P73, these first part 31 and second part 32 each processing the voltage signals to deliver respectively a first sinusoidal signal C31 and a second sinusoidal signal S32. The system 1 also comprises control means 4 for controlling the variable parameters P64 and/or P73 of the passive analogical components R64 and/or R73. According to the invention, a variation of at least one of the variable parameters P64 and/or P73 shifts at least one of the analogical output signals C31 and S32 of the sensor device 2+3. This at least one shifted analogical output signal of the sensor device 2+3 includes the first sinusoidal signal C31 and/or the second sinusoidal signal S32, preferably both signals C31 and S32.

In other words, system 1 delivers at least two analogical output signals, including at least one shifted analogical output signal.

In addition, technical features of the different embodiments can be, in whole or part, combined with each other. Thus, the system 1 can be adapted in terms of cost, functionality or to any specific requirements of the application.

CLAIMS

1. A system (1) for shifting at least one analogical output signal (C31, S32 ; C31; S32) of a sensor device (2+3), comprising:
   - a sensor (2) including at least two detection cells (21, 22, 23, 24, 25) adapted to equip a mechanical device (10) and to deliver voltage signals (U21, U22, U23, U24, U25) depending on behaviour of the mechanical device (10), and
   - an electronic circuit (3) processing the voltage signals (U21, U22, U23, U24, U25) to deliver the at least one analogical output signal (C31, S32 ; C31 ; S32) of the sensor device (2+3) depending on behaviour of the mechanical device (10),

   wherein the electronic circuit (3) comprises at least:
   - a first part (31) including at least one passive analogical component (R64) having a variable parameter (P64), the first part (31) processing the voltage signals (U21, U22, U23, U24, U25) to deliver a first sinusoidal signal (C31), and
   - a second part (32) including at least one passive analogical component (R73) having a variable parameter (P73), the second part (32) processing the voltage signals (U21, U22, U23, U24, U25) to deliver a second sinusoidal signal (S32);

   wherein the system (1) also comprises control means (4) for controlling the variable parameters (P64; P73) of the passive analogical components (R64; R73), a variation of at least one of the variable parameters (P64; P73) shifting at least one analogical output signal (C31, S32; C31; S32) of the sensor device (2+3); and
   wherein this at least one shifted analogical output signal (C31, S32; C31; S32) of the sensor device (2+3) includes the first sinusoidal signal (C31) and/or the second sinusoidal signal (S32).

2. System (1) according to any one of the previous claims, wherein the detection cells (21, 22, 23, 24, 25) of the sensor (2) and at least the first part (31) and the second part (32) of the electronic circuit (3) are located together in a housing of the sensor device (2+3).

3. System (1) according to any one of the previous claims, wherein the electronic circuit (3) delivers two shifted analogical output signals (C31, S32), which are the first sinusoidal signal (C31) and the second sinusoidal signal (S32).

4. System (1) according to any one of the previous claims, wherein each of the first part (31) and second part (32) of the electronic circuit (3) includes only one passive analogical component (R64; R73) having a variable parameter (P64; P73).

5. System (1) according to any one of the previous claims, wherein the control means (4) modify the variable parameters (P64; P73) of the passive analogical components (R64; R73) simultaneously.

6. System (1) according to claims 4 and 5, wherein the control means (4) modify the two variable parameters (P64; P73) of the two passive analogical components (R64; R73) simultaneously in a reversed way.

7. System (1) according to any one of the previous claims, wherein the first sinusoidal signal (C31) is a cosine signal, wherein the second sinusoidal signal (S32) is a sine signal, and wherein an arctangent function applied to a division of the sine signal (S32) by the cosine signal (C31) corresponds to a rotation angle of a rotating part (12) relative to a stationary part (11) of the mechanical device (10).

8. System (1) according to any one of the previous claims, wherein the control means (4) comprise at least one potentiometer (41) associated with at least one of the passive analogical components (R64; R73) and adapted to selectively modify the variable parameter (P64; P73) of this passive analogical component (R64; R73).

9. System (1) according to any one of the previous claims, wherein the control means (4) comprise an emitter (41) adapted to selectively act on at least one of the passive analogical components (R64; R73) and to modify the variable parameter (P64; P73) of this passive analogical component (R64; R73).

10. System (1) according to claim 9, wherein the emitter (41) is a laser emitter adapted to selectively emit a laser ray on at least one of the passive analogical components (R64; R73) and to modify the variable parameter (P64; P73) of this passive analogical component (R64; R73).

11. System (1) according to any one of the previous claims, wherein at least one of the passive analogical components (R64, R73) is a resistor component and its variable parameter (P64; P73) is a resistance value.

12. System (1) according to any one of the previous claims, wherein at least one of the passive analogical components is an inductor component and its variable parameter is an inductance value.

13. System (1) according to any one of the previous claims, wherein the sensor (2) comprises at least three detection cells (21, 22, 23), preferably five detection cells (21, 22, 23, 24, 25).

14. Sensor-bearing unit including a bearing and a system (1) according to one of the previous claims, wherein the sensor (2) of the system (1) and the bearing equip a stationary part (11) and a rotating part (12) of the mechanical device (10).

15. Method for shifting at least one analogical output signal (C31, S32; C31; S32) of a sensor device (2+3), which comprises:
- a sensor (2) including at least two detection cells (21, 22, 23, 24, 25) adapted to equip a mechanical device (10), and
- an electronic circuit (3) delivering the at least one analogical output signal (C31, S32; C31; S32) of the sensor device (2+3) depending on behaviour of the mechanical device (10);

wherein the method includes at least the following steps:
- the detection cells (21, 22, 23, 24, 25) deliver voltage signals (U21, U22, U23, U24, U25) depending on behaviour of the mechanical device (10);
- a first part (31) of the electronic circuit (3), including at least one passive analogical component (R64) having a variable parameter (P64), processes the voltage signals (U21-U25) to deliver a first sinusoidal signal (C31);
- a second part (32) of the electronic circuit (3), including at least one passive analogical component (R73) having a variable parameter (P73), processes the voltage signals (U21-U25) to deliver a second sinusoidal signal (S32); and
- control means (4), forming a shifting system (1) together with the sensor device (2+3), control the variable parameters (P64; P73) of the passive analogical components (R64; R73), a variation of at least one of the variable parameters (P64; P73) shifting at least one analogical output signal (C31, S32; C31; C32) of the sensor device (2+3), wherein this at least one shifted analogical output signal (C31, S32; C31; S32) includes the first sinusoidal signal (C31) and/or the second sinusoidal signal (S32).

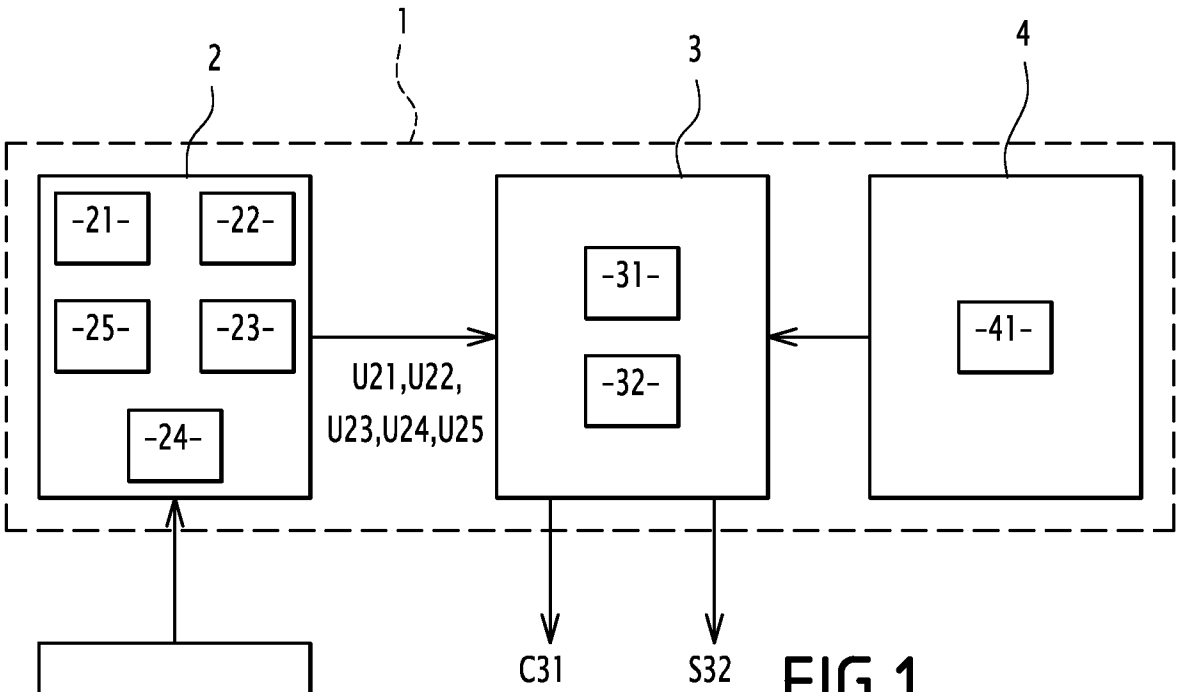

1
2
3
4
-21-
-22-
-25-
-23-
-24-
-31-
-32-
-41-
U21,U22,
U23,U24,U25
C31
S32
-11-
-12-
10

FIG.1

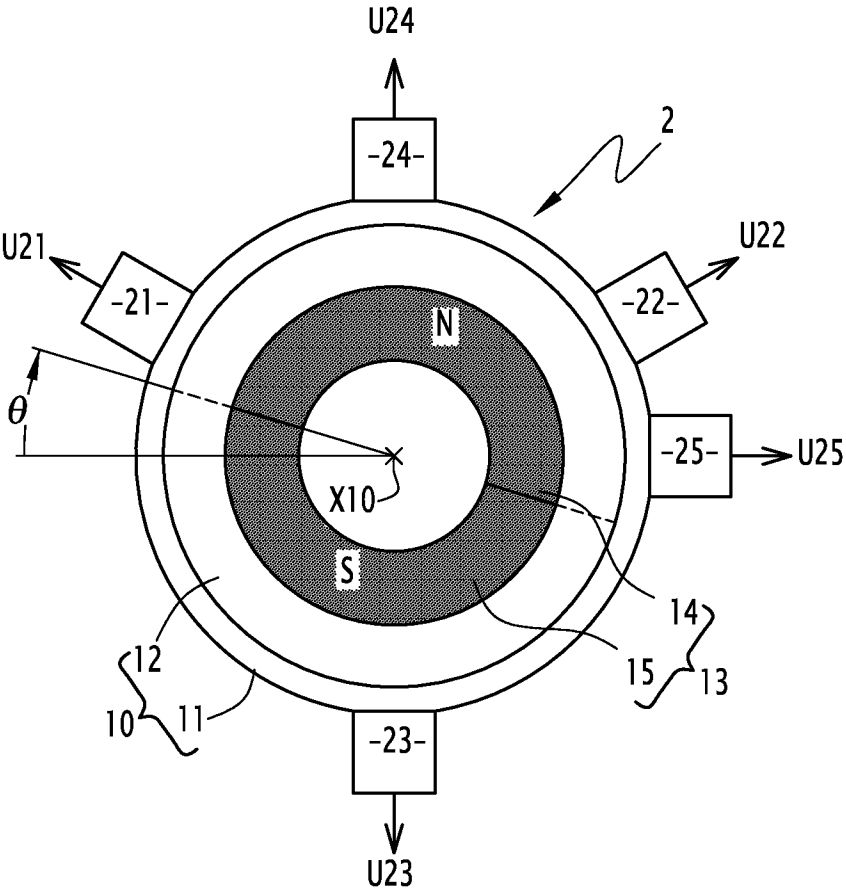

U24
2
-24-
U21
U22
-21-
-22-
N
θ
-25-
U25
X10
S
14
12
15
13
10
11
-23-
U23

FIG.2

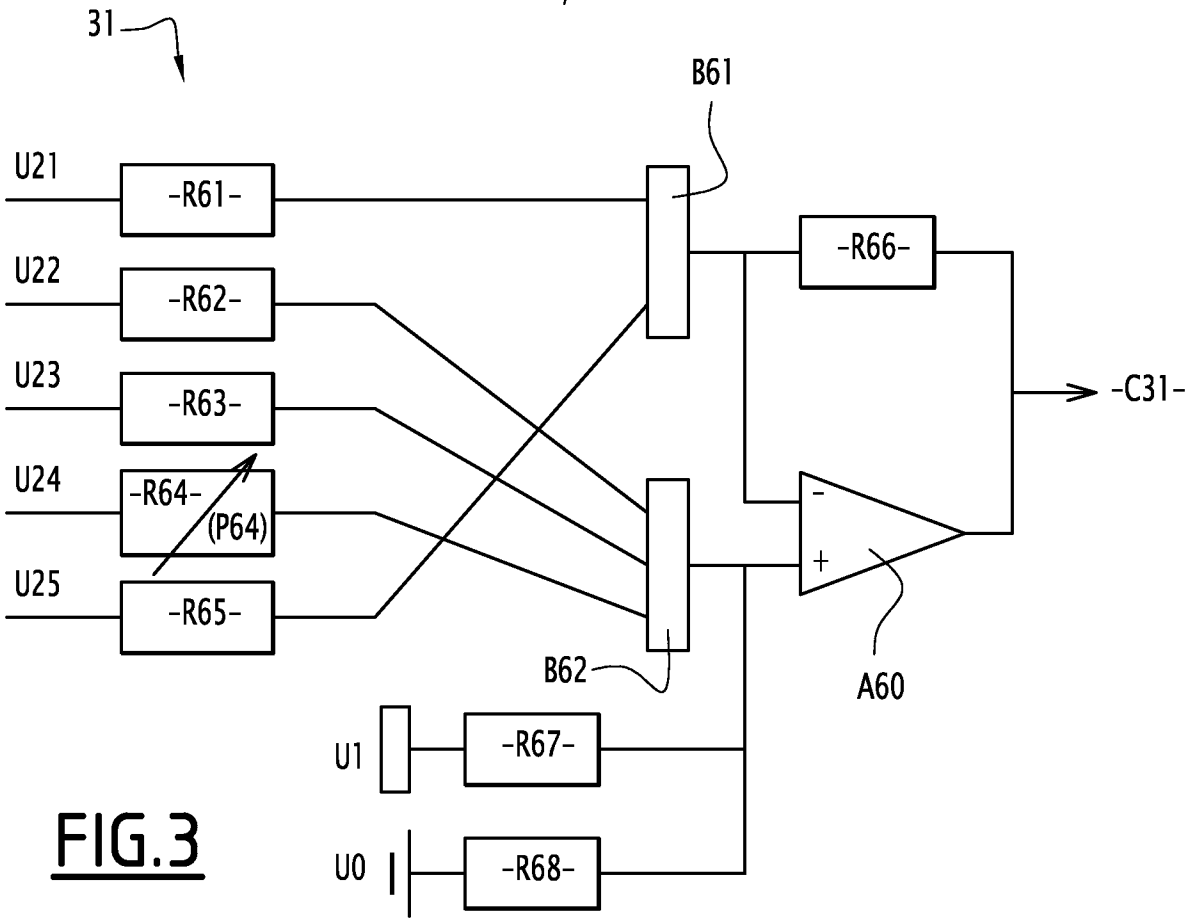

31
B61
U21
-R61-
U22
-R62-
U23
-R63-
U24
-R64-
(P64)
U25
-R65-
-R66-
-C31-
B62
A60
U1
-R67-
U0
-R68-

FIG.3

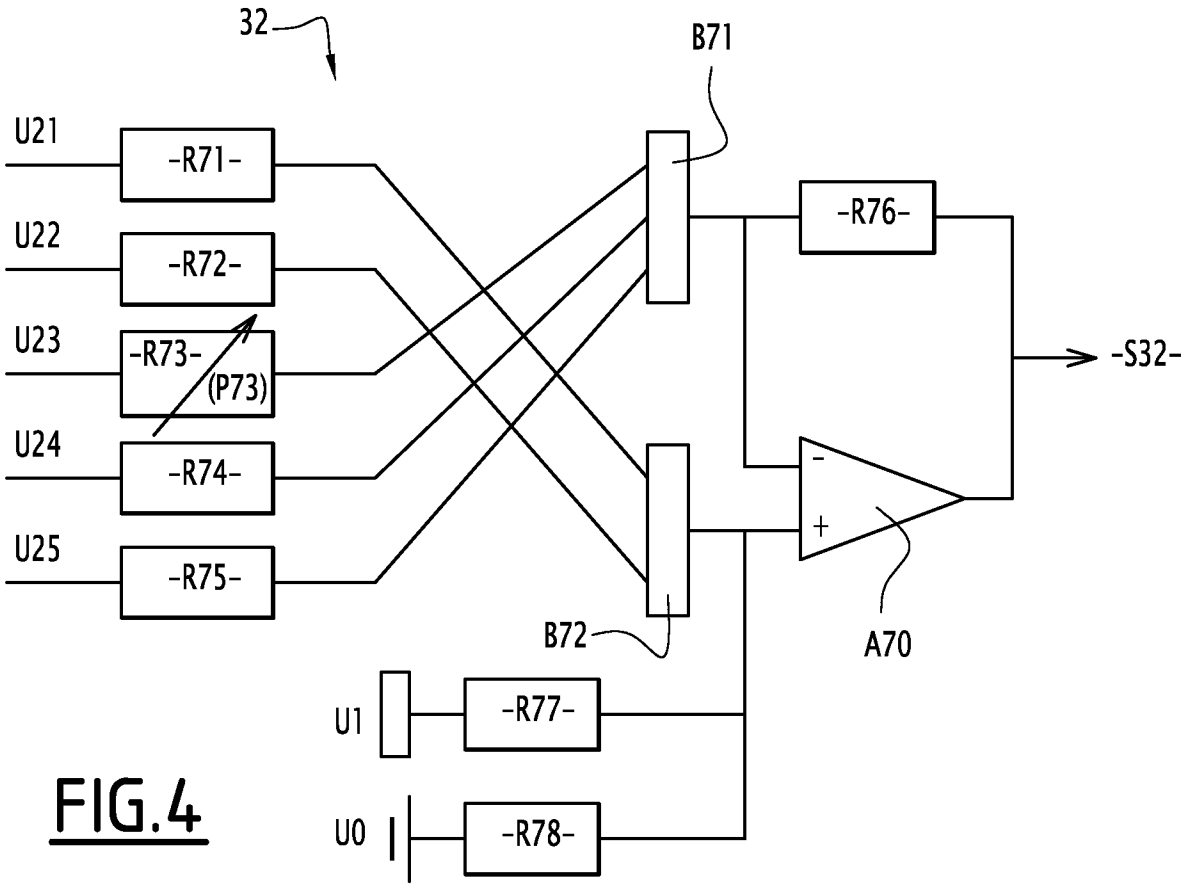
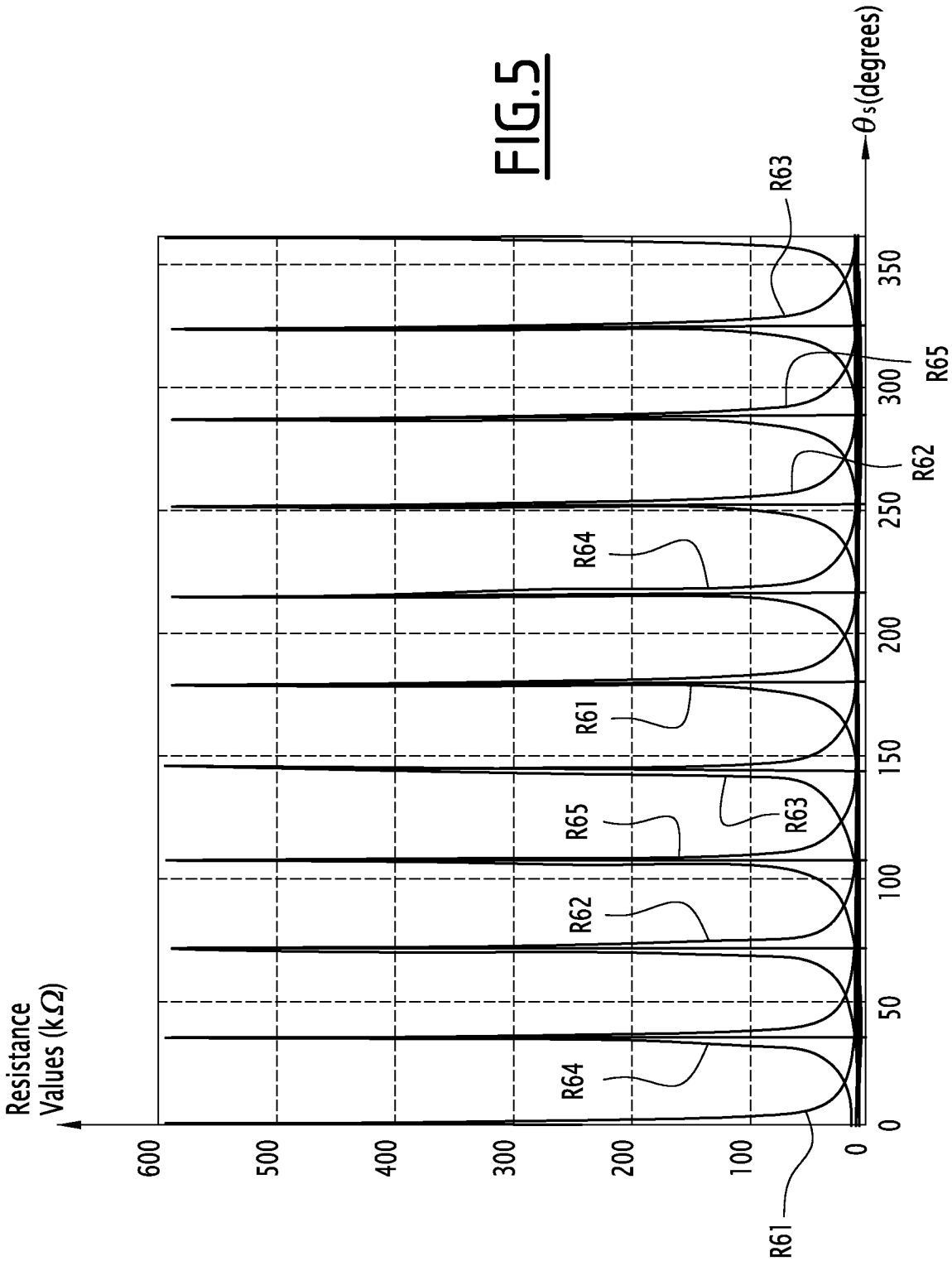

32
B71
U21
-R71-
U22
-R72-
U23
-R73-
(P73)
U24
-R74-
U25
-R75-
-R76-
-S32-
B72
A70
U1
-R77-
U0
-R78-

FIG.4

FIG.5


Resistance Values (kΩ)
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
θs(degrees)
R61
R62
R63
R64
R65
R64
R61
R65
R63
R62
R63
R65
R62
R64
R61

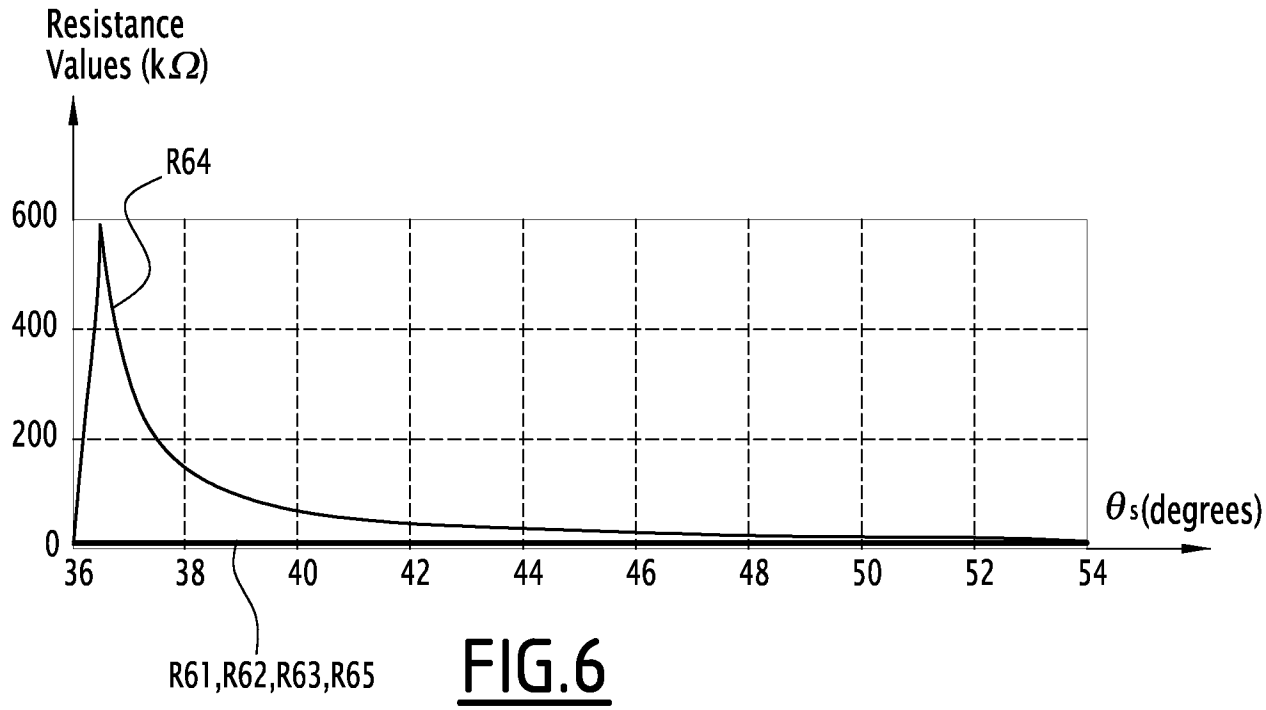

Resistance
Values (kΩ)
R64
600
400
200
0
36
38
40
42
44
46
48
50
52
54
θs(degrees)
R61,R62,R63,R65

FIG.6

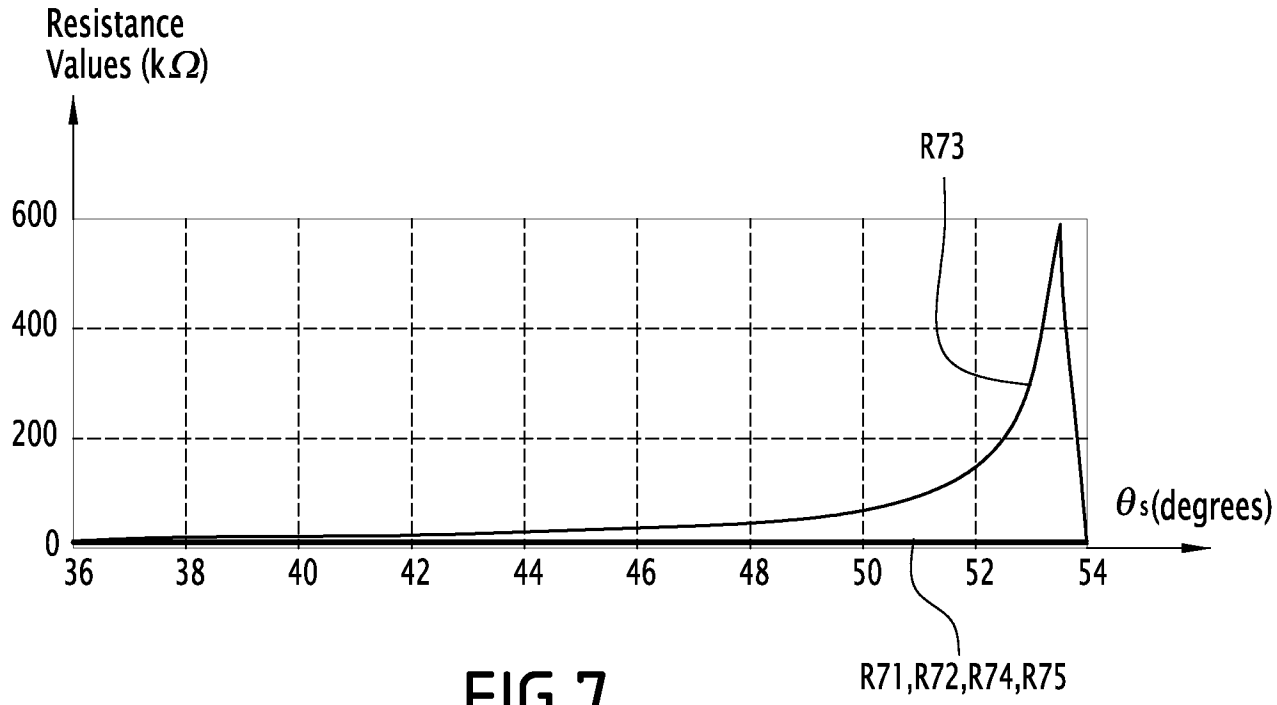

Resistance
Values (kΩ)
R73
600
400
200
0
36
38
40
42
44
46
48
50
52
54
θs(degrees)
R71,R72,R74,R75

FIG.7

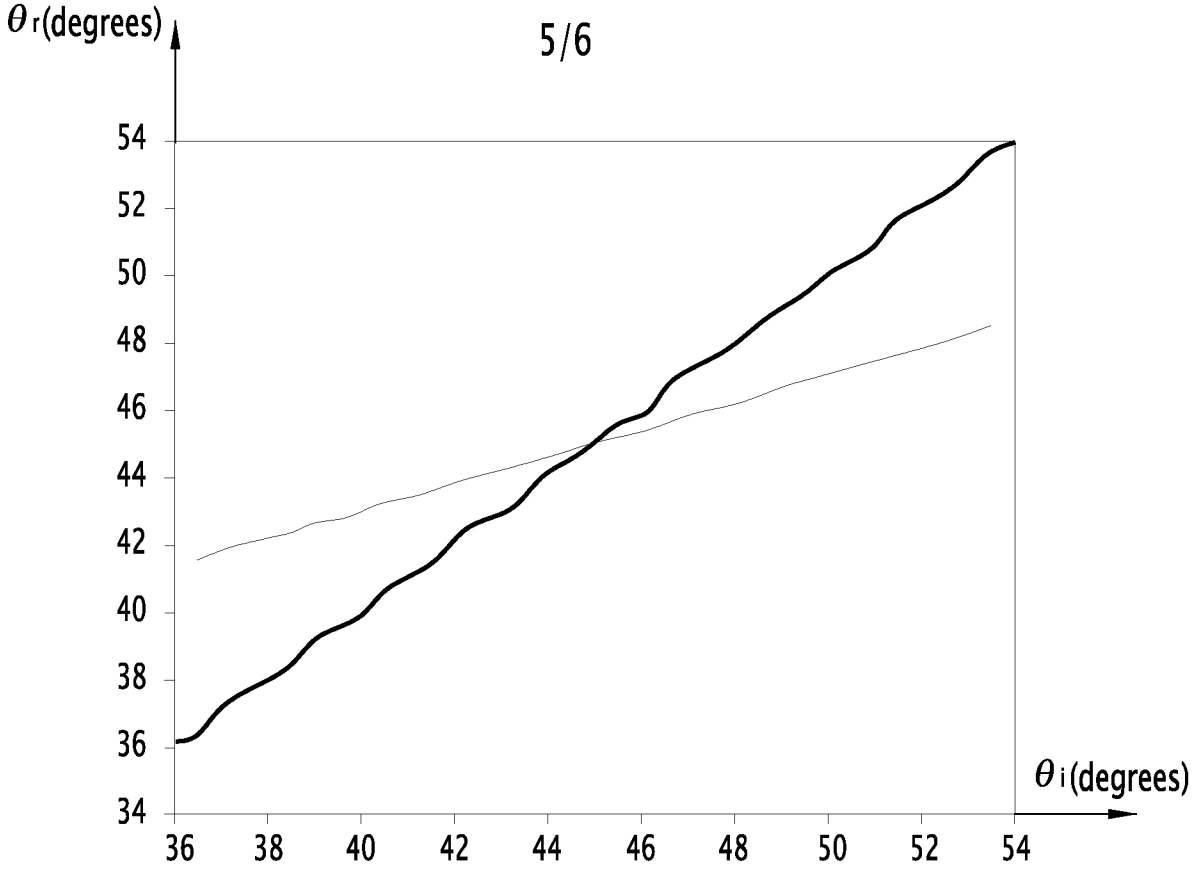

θr(degrees)
54
52
50
48
46
44
42
40
38
36
34
36
38
40
42
44
46
48
50
52
54
θi(degrees)

FIG.8

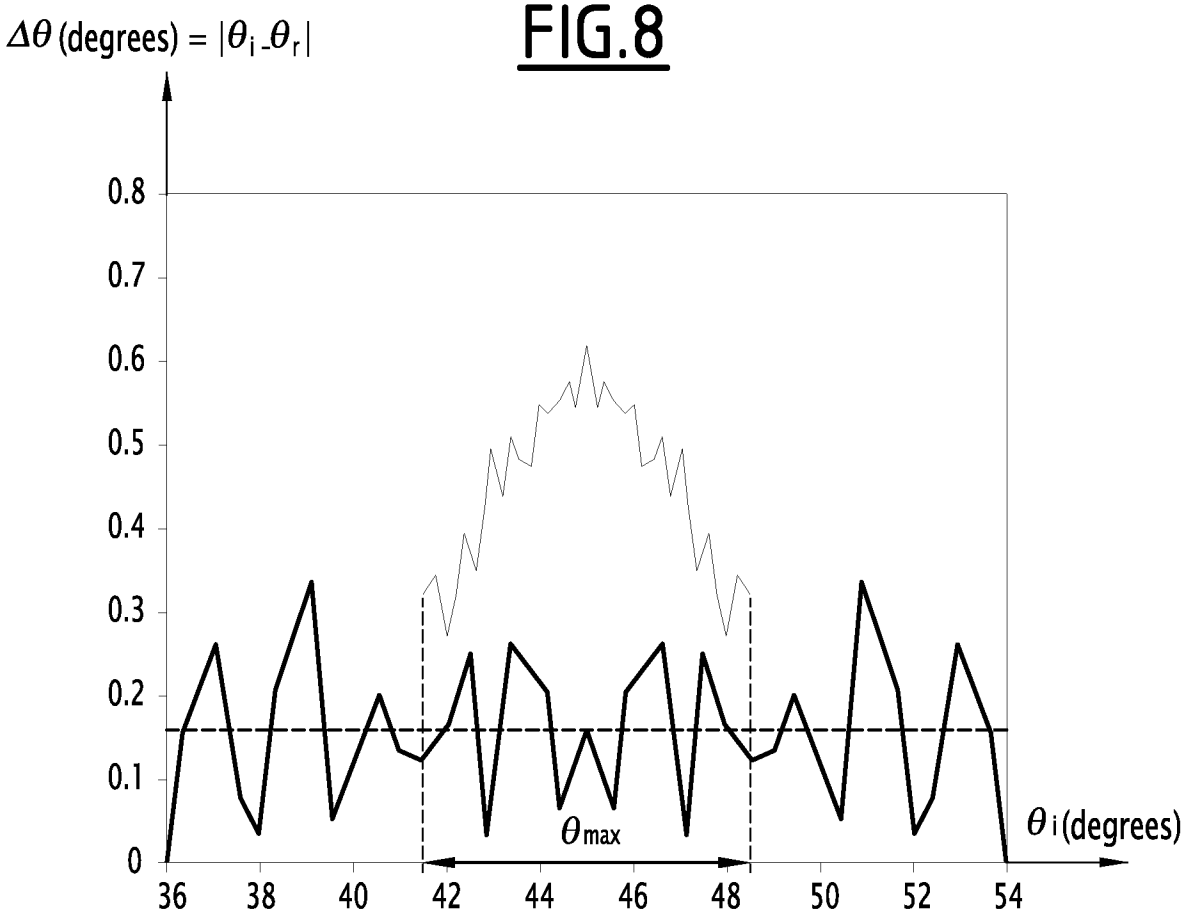

Δθ (degrees) = |θi - θr|
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
θmax
36
38
40
42
44
46
48
50
52
54
θi(degrees)

FIG.9

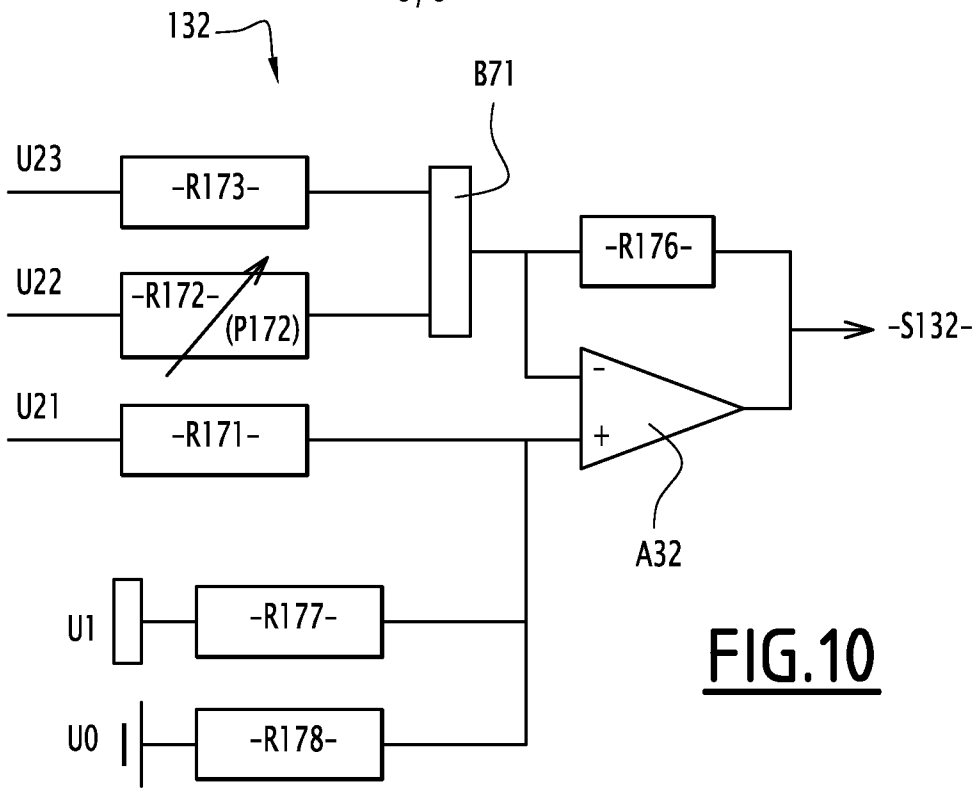

132
B71
U23
-R173-
U22
-R172-
(P172)
U21
-R171-
-R176-
-S132-
-
+
A32
U1
-R177-
U0
-R178-

FIG.10

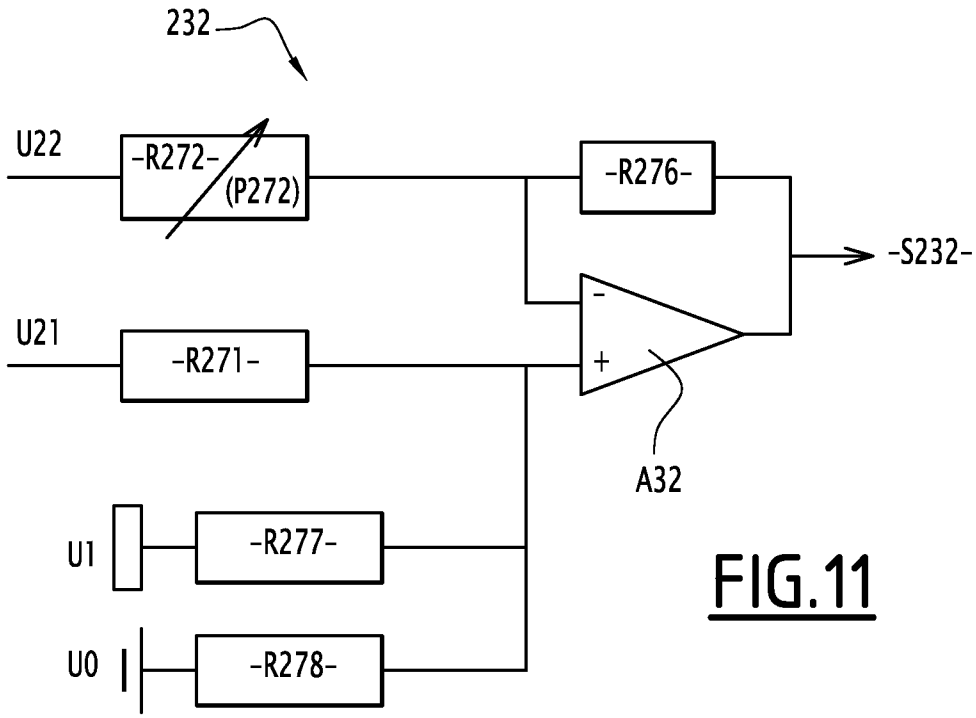

232
U22
-R272-
(P272)
U21
-R271-
-R276-
-S232-
-
+
A32
U1
-R277-
U0
-R278-

FIG.11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/070725

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01D5/244 G01P3/44 G01P3/489 B62D15/02
ADD.

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)
G01D G01P B62D

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/070391 A1 (AKTIEBOLAGET SKF) 16 June 2011 (2011-06-16) the whole document	1-15
A	FR 2 852 464 A1 (AKTIEBOLAGET SKF) 17 September 2004 (2004-09-17) abstract; figure 3 pages 1-9	1,14,15
A	US 2003/057903 A1 (DESBIOLLES ET AL) 27 March 2003 (2003-03-27) paragraphs [0049], [0082] - [0084]; claim 15	1,14,15
A	US 6 859 002 B2 (DESBIOLLES ET AL) 22 February 2005 (2005-02-22) paragraphs [0074], [0076]	1,14,15

-/--

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
10 July 2013	17/07/2013

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, Fax: (+31-70) 340-3016	Barthélemy, Matthieu

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/070725

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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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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