

METHOD OF MINIATURE TWO AXES FOUR-WHEEL DRIVE CONTROL WITH PRECISION MAGNETIC ENCODER DESIGN

Field of the Invention

5 This invention relates to a magnetic encoder. More particularly, this invention relates to a magnetic encoder for a miniature two axes four-wheel drive control. Still more particularly, this invention relates to a single platform that houses a motor with a twin-gear drive module and a magnetic encoder feedback system for moving an object.

Prior Art

10 In a conventional method of driving a two axes four-wheel moving object, the design involves using two motors placed back-to-back, with each motor driving two gears through a pinion mounted on the motor as shown in figure 1. This conventional method suffers from several drawbacks. As a single pinion is required to drive two gears placed on opposing
15 sides of the pinion, there exist great opposing forces on the pinion and also large friction between the pinion and the gears. Loss of kinetic energy through friction will result in lower power transferred from the motors to the wheels. There is also a limitation as to how narrow the width of the moving object can be since the width must at least be greater than the length of the two motors placed back-to-back. Thus, those skilled in the art are
20 constantly striving to design an improved configuration to a two axes four-wheel moving object.

Traditionally, optical encoders are used with motors for motion control feedback. These optical encoders suffer from the drawback of being larger in size and difficulty in
25 miniaturization. Recently, use of magnetic encoders for feedback has become more popular for motion control feedback for small motors for two reasons. First, magnetic encoders are available in smaller sizes. Secondly, magnetic encoders offer greater precision than optical encoders for very small size encoders. It has become a trend

nowadays that manufacturers attach magnetic encoder instead of optical encoders for small motors.

A magnetic encoder consists of a rotating gear made of ferrous metal and a magnetic pick-up that contains a permanent magnet and the sensing element. The gear, which is mounted on the rotating shaft, has precisely machined teeth that provide the code pattern. As the disk rotates, these teeth disturb the magnetic flux emitted by the permanent magnet, causing the flux field to expand and collapse. These changes in the field are sensed by the sensing element, which generates a corresponding digital or pulse signal output. The use of magnetic encoder typically creates a magnetic field which may interact with any nearby magnetic fields. This magnetic interference is undesirable and will interfere with other nearby magnetic fields from other magnetic encoders or DC motors in the vicinity. Thus, those skilled in the art are constantly striving to design an improved magnetic encoder that works for a miniature drive system for moving an object.

Summary of the Invention

The above and other problems are solved and an advance in the art is made by a magnetic encoder installed on a driver assembly for moving an object in accordance with this invention. A first advantage of a magnetic encoder installed on a driver assembly for moving an object in accordance with this invention is that magnetic encoder is a highly compact arrangement. Hence, it can be applied in precision engineering and/or surgical robotic arenas where miniature components are required. A second advantage of a magnetic encoder installed on a driver assembly for moving an object in accordance with this invention is that the magnetic encoder produces minimum magnetic interference that may affect other adjacent devices. A third advantage of a magnetic encoder installed on a driver assembly for moving an object in accordance with this invention is that the magnetic encoder uses readily available components to assemble. Hence, it is cost efficient to build the magnetic encoder. A fourth advantage of a magnetic encoder installed on a driver assembly for moving an object in accordance with this invention is that the compact twin-

gear drive system developed offers supreme solution that fulfils the needs of highly compact multi-axes driving system.

In accordance with embodiments of this invention, a magnetic encoder for a driver
5 assembly is configured in the following manner. The magnetic encoder comprises a permanent axial magnet having a north pole and a south pole, a magnet holder having a cavity to receive the permanent axial magnet, and a sensing element positioned apart from the magnet holder and facing an exposed portion of the north and south poles of the permanent axial magnet. Preferably, the permanent axial magnet has a longitudinal axis
10 running through the north pole and the south pole, and the magnet holder and the sensing element share a longitudinal axis that is perpendicular to the longitudinal axis of the permanent axial magnet. Still more preferably, a portion of the cavity is adapted to mate with a portion of the permanent axial magnet.

15 In accordance with embodiments of this invention, a moving object is provided which includes a base and a magnetic encoder being arranged on the base to monitor the movement mechanism of the moving object.

In accordance with embodiments of this invention, a miniature two axes four-wheel
20 drive control for an object is provided as follows. The drive control includes a base, a first driver and a second driver, and a controller. The first driver includes a first wheel assembly, a second wheel assembly, a motor assembly for driving the second wheel assembly, an encoder assembly arranged between the first and second wheel assemblies, and a frame for holding the first wheel assembly, the second wheel assembly, the motor assembly, and
25 the encoder assembly. The second driver is identical to the first driver. The controller is provided for controlling a movement of the object. In use, the motor assembly drives the second wheel assembly which causes the encoder assembly to cause the first wheel

assembly to move. Preferably, the frame comprises a pair of eyelets for securing the frame to the base. Still preferably, the first driver and the second driver are diagonally arranged apart from each other.

5 In accordance with embodiments of this invention, the encoder assembly includes a permanent axial magnet having a north pole and a south pole, a magnet holder having a cavity to receive the permanent magnet, and a sensing element secured to the base and position apart from the magnet holder and facing an exposed portion of both north and south poles of the permanent axial magnet. Preferably, the permanent axial magnet has a
10 longitudinal axis running through the north pole and the south pole, and the magnet holder and the sensing element share a longitudinal axis that is perpendicular to the longitudinal axis of the permanent axial magnet. Still more preferably, a portion of the cavity of the magnet holder is adapted to mate with a portion of the permanent axial magnet.

15 In accordance with embodiments of this invention, the encoder assembly further includes a bearing having a bearing mechanism, a flange and a through opening, and a pinion having a through opening. In accordance with some embodiments of this embodiment, the magnet holder has an extension having a first portion for receiving the through opening of the bearing and a second portion for receiving the through opening of
20 the pinion. Preferably, the second portion of the extension of the magnet holder is diametrically smaller than the first portion of the extension of the magnet holder. Still more preferably, a first locking mechanism is provided to secure the bearing, pinion, and magnet holder to the frame.

25 In accordance with embodiments of this invention, the first wheel assembly comprises a bearing having a bearing mechanism, a flange and a through opening, a gear having teeth around a perimeter of the gear and an extension, a rim having an insert

adapted to receive the extension of the gear, a flange and a through opening adapted to receive the bearing, and a second locking mechanism for securing the bearing, the gear, and the rim to the frame.

5 In accordance with embodiments of this invention, the motor assembly comprises a motor having a shaft and a pinion connected to the shaft.

 In accordance with embodiments of this invention, the second wheel assembly comprises a bearing having a bearing mechanism, a flange and a through opening, a gear
10 having inner teeth engagably connectable to the teeth of said pinion of said motor assembly and outer teeth engagably connectable to the teeth of the pinion of the encoder assembly, a rim having an insert adapted to receive the extension of said gear, a flange and a through opening adapted to receive the bearing, and a third locking mechanism for securing the bearing, gear, and rim to the frame.

15

Brief Description of the Drawings

The above and other features and advantages in accordance with this invention are described in the following detailed description and are shown in the following drawings:

Figure 1 illustrating a top view of a drive system known in the art;

20 Figure 2 illustrating a top view of a moving object having a miniature two axes four-wheel drive control assembly in accordance with an embodiment of this invention;

Figure 3 illustrating a top view of a driver assembly in accordance with an embodiment of this invention;

25 Figure 4 illustrating a perspective view of a frame in accordance with an embodiment of this invention;

Figure 5 illustrating another perspective view of the frame in accordance with an embodiment of this invention;

Figure 6 illustrating a perspective view of a motor assembly and a second wheel assembly in accordance with an embodiment of this invention;

Figure 7 illustrating an exploded view the motor assembly and the second wheel assembly in accordance with an embodiment of this invention;

5 Figure 8 illustrating a front view of a pinion of the motor assembly in accordance with an embodiment of this invention;

Figure 9 illustrating a perspective view of the pinion of the motor assembly in accordance with embodiment of this invention;

10 Figure 10 illustrating a front view of a gear of the first and second wheel assemblies in accordance with an embodiment of this invention;

Figure 11 illustrating a perspective view of the gear of the first and second wheel assemblies in accordance with an embodiment of this invention;

Figure 12 illustrating a perspective view of the arrangement of gears and pinion in accordance with an embodiment of this invention;

15 Figure 13 illustrating a perspective view of the front wheel assembly in accordance with an embodiment of this invention;

Figure 14 illustrating an exploded view of the front wheel assembly in accordance with an embodiment of this invention;

20 Figure 15 illustrating a perspective view of an encoder assembly in accordance with an embodiment of this invention;

Figure 16 illustrating an exploded view of the encoder assembly in accordance with an embodiment of this invention;

Figure 17 illustrating a front view of a pinion of the encoder assembly in accordance with an embodiment of this invention;

25 Figure 18 illustrating a perspective view of the pinion of the encoder assembly in accordance with an embodiment of this invention;

Figure 19 illustrating a magnet and its magnetic field in accordance with an embodiment of this invention;

Figure 20 illustrating a first arrangement of the magnet to a magnet holder; and

Figure 21 illustrating a second arrangement of the magnet to the magnet holder in
5 accordance with an embodiment of this invention.

Detailed Description

This invention relates to a magnetic encoder. More particularly, this invention relates to a magnetic encoder for a miniature two axes four-wheel drive control. Still more
10 particularly, this invention relates to a single platform that houses a motor with a twin-gear drive module and a magnetic encoder feedback system for moving an object.

Figure 2 shows a top view of an embodiment of a moving object 100 having a miniature two axes four-wheel drive control with two magnetic encoders. Moving object 100
15 includes a base 110, two drivers 120 and 130 being secured to the base 110, and a controller 180. Each of the drivers 120 and 130 is provided with motors 160 and 170 and magnetic encoders 140 and 150. The drivers 120 and 130 are identical and are placed diagonally opposed to each other as shown in figure 2. As shown in figure 2, arranging the
20 drivers 120 and 130 diagonally opposite of each other allows the width of the base, w , to be reduced as compared to the configuration shown in figure 1. Controller 180 is a processing device for controlling the motors 160 and 170, and receiving feedbacks from the magnetic encoders 140 and 150. One skilled in the art will recognise that the controller 180 may perform other functions of moving object 100 without departing from the invention.

25 Figure 3 illustrates a top view of driver 120. Driver 120 includes a frame 210, a motor assembly 220, an encoder assembly 230, a first wheel assembly 240, and a second wheel assembly 250. Further details of each of the components of driver 120 will be described further below with reference to figures 4-14.

Figure 4 illustrates a perspective view the frame 210. Figure 5 illustrates another perspective view of the frame 210. The frame 210 includes a first cavity 211, a second cavity 212, a first aperture 213, a second aperture 214, a first shaft 215, a second shaft 216,
5 a first eyelet 217, and a second eyelet 218.

The first and second eyelets 217 and 218 are provided for securing the frame 210 onto the base 110 of the moving object 100.

10 The first cavity 211 is provided for receiving a magnet holder of magnetic encoder 140 or 150. One skilled in the art will recognise that the configuration of the first cavity 211 is dependent on the shape of the magnet holder. Hence, although figures 4 and 5 show that the first cavity 211 is circular is shape, first cavity 211 may also be configured in other geometric shape without departing from the invention as long as first cavity 211 is able to
15 receive the magnet holder.

The second cavity 212 is provided for receiving the motor assembly 220. One skilled in the art will recognise that the configuration of the second cavity 212 is dependent on the shape of the motor assembly 220. Hence, although figures 4 and 5 show that the second
20 cavity 212 is circular is shape, second cavity 212 may also be configured in other geometric shape without departing from the invention as long as second cavity 212 is able to receive the motor.

The first shaft 215 is provided to receive the first wheel assembly 240 and has a
25 longitudinal axis, X3. An opening 215a is provided for a locking mechanism (not shown) to secure the first wheel assembly 240 to frame 210. The locking mechanism may simply be a threaded screw, or other quick release device capable of securing the first wheel assembly

240 to frame 210 without departing from the invention. Further details of first wheel assembly 240 will be described below with reference to figure 9-10 and 12-13.

The second shaft 216 is provided to receive the second wheel assembly 250 and has a longitudinal axis, X1. An opening 216a is provided for a locking mechanism to secure the second wheel assembly 250 to frame 210. The locking mechanism may simply be a threaded screw, or other quick release device capable of securing the second wheel assembly 250 to frame 210 without departing from the invention. Further details of second wheel assembly 250 will be described below with reference to figures 5-6 and 9-10.

The first aperture 213 is provided with the first cavity 211 for connection of the encoder assembly 230. Both the first aperture 213 and first cavity 211 has a longitudinal axis X4. Further details of the encoder assembly 230 will be described below with reference to figures 14-21. The second aperture 214 is provided with the second cavity 212 for connection of the motor assembly 220. Both the second aperture 214 and second cavity 212 has a longitudinal axis X2. Further details of motor assembly 220 will be described below with reference to figures 5-6 and 9-10.

Figure 6 illustrates the motor assembly 220 and second wheel assembly 250 in accordance with an embodiment of this invention. Figure 7 illustrates an exploded view of the motor assembly 220 and second wheel assembly 250 in accordance with an embodiment of this invention. The second wheel assembly 250 has an axis X1 and the motor assembly 220 has an axis X2.

The motor assembly 220 includes a motor 160 or 170 and a pinion 222. Pinion 222 has a through opening 226 and teeth 227. Figure 7 shows a front view of pinion 222 and figure 8 shows a perspective view of pinion 222. As shown in figure 8 and 9, pinion 222

includes eight teeth 227. However, one skilled in the art will recognise that any other number of teeth may be implemented without departing from the invention. Motor 160 or 170 is a conventional electric motor that converts electrical energy to mechanical energy. In this instance, the motor 160 or 170 is used for rotating the pinion 222. Motor 160 or 170 includes a pair of connectors 223 and 224 for receiving power from a power source (not shown) that is provided on the moving object 100, and a shaft 225 for translating mechanical energy to the pinion 222. Shaft 225 of motor 160 or 170 is inserted through the through opening 226 of the pinion 222 along axis X2. The motor assembly 220 is assembled in the following manner. Motor 160 or 170, is inserted into the second cavity 212 of frame 210 with the shaft 225 passing through the second through opening 214 of frame 210. Pinion 222 is then securely inserted into shaft 225 along axis X2.

The second wheel assembly 250 includes a gear 251, a bearing 252, and a rim 253. The gear 251, bearing 252 and rim 253 are connected along axis X1. The rim 253 is arranged between the gear 251 and bearing 252. The rim 253 includes an insert 253a, a through opening 253b and a flange 253c. The rim 253 also includes an outer surface 253d for receiving a tyre (not shown). The gear 251 includes outer teeth 251a, inner teeth 251b, extension 251c, and a through opening 251d. Figure 10 shows a front view of gear 251 and figure 11 shows a perspective view of gear 251. As shown in figures 10 and 11, gear 251 includes thirty-one outer teeth 251a and twenty-four inner teeth 251b. However, one skilled in the art will recognise that any other number of inner and outer teeth may be implemented without departing from the invention. The bearing 252 includes a bearing mechanism 252a, a flange 252b, and a through opening 252c. The second wheel assembly 250 is assembled in the following manner. The bearing mechanism 252a is inserted into through opening 253b of rim 253. The flange 252b of bearing 252 abuts an end of through opening 253b of rim 253. The extension 251c of gear 251 is inserted into insert 253a such that flange 253c abuts outer teeth 251a. The second wheel assembly 250 is secured to the frame 210 by a

releasable locking mechanism (not shown) that is inserted from through opening 252c of bearing 252 into the opening 216a of second shaft 216 of frame 210 along axis X1. The locking mechanism may simply be a threaded screw, or other quick release device capable of securing the second wheel assembly 250 to frame 210 without departing from the invention.

The axis X1 and X2 are selected such that when the motor assembly 220 and second wheel assembly 250 are secured to the frame 210, teeth 227 of pinion 222 is engagably connectable to inner teeth 251b of gear 251 as shown in figure 12.

10

Figure 13 is a perspective view of first wheel assembly 240. Figure 14 is an exploded view of the first wheel assembly 240. The first wheel assembly 240 has an axis X3. First wheel assembly 240 is identical to second wheel assembly 250. The first wheel assembly 240 includes a gear 241, a bearing 242, and a rim 243. The gear 241, bearing 242 and rim 243 are connected along axis X3. The rim 243 is arranged between the gear 241 and bearing 242. The rim 243 includes an insert 243a, a through opening 243b and a flange 243c. The rim 243 also includes an outer surface 243d for receiving a tyre (not shown). The gear 241 includes outer teeth 241a, inner teeth 241b, extension 241c, and a through opening 241d. Figure 10 shows a front view of gear 241 and figure 11 shows a perspective view of gear 241. As shown in figures 10 and 11, gear 241 includes thirty-one outer teeth 241a and twenty-four inner teeth 241b. However, one skilled in the art will recognise that any other number of inner and outer teeth may be implemented without departing from the invention. One skilled in the art will also recognise that inner teeth may be excluded from gear 241 since a motor assembly is not connected to first wheel assembly 240. The bearing 242 includes a bearing mechanism 242a, a flange 242b, and a through opening 242c. The first wheel assembly 240 is assembled in the following manner. The bearing mechanism 242a is inserted into through opening 243b of rim 243. The flange 242b of

25

bearing 242 abuts an end of through opening 243b. The extension 241c is inserted into insert 243a such that flange 243c abuts outer teeth 241a. The first wheel assembly 240 is secured to the frame 210 by a releasable locking mechanism (not shown) that is inserted from through opening 242c of bearing 242 into the opening 215a of first shaft 215 of frame 210 along axis X3. The locking mechanism may simply be a threaded screw, or other quick release device capable of securing the first wheel assembly 240 to frame 210 without departing from the invention.

Figure 15 is a perspective view of the encoder assembly 230. Figure 16 is an exploded view of the encoder assembly 230. The encoder assembly 230 includes a sensing element 231, a magnet holder 232, a magnet 233, a bearing 234 and a pinion 235.

Pinion 235 has a through opening 235a and teeth 235b. Figure 17 shows a front view of pinion 235 and figure 18 shows a perspective view of pinion 235. As shown in figures 17 and 18, pinion 235 includes twelve teeth 235b. However, one skilled in the art will recognise that any other number of teeth may be implemented without departing from the invention.

Bearing 234 includes a bearing mechanism 234a, a flange 234b, and a through opening 234c. The magnet holder 232 includes a cavity 232a, an extension 232b having a first portion 232b1 and a second portion 232b2. The dimension of the first portion 232b1 is larger than the second portion 232b2. Magnet 233 is a permanent axial magnet. Further details of magnet 233 will be described below with reference to figures 19-21. Sensing element 231 is any sensing device that will detect the changes in magnetic field, generate a corresponding signal and transmit the signal to the controller 180. Sensing element 231 performs as a feedback to monitor the movement of the gears. Further details of magnet 233 and sensing element 231 will be described below with reference to figures 19-21.

The encoder assembly 230 is assembled in the following manner. The magnetic holder 232 is inserted into first cavity 211 of frame 210. The bearing 234 is inserted into extension 232b and rest on first portion 232b1. The pinion 235 is then inserted into extension 232b and rest on the second portion 232b2. The magnet 233 is slotted into cavity 232a. A releasable locking mechanism (not shown) that then is inserted from through opening 235a of pinion 235 into an opening 232b3 (obscured) of extension 232b of magnetic holder 232 along axis X4. The sensing element 231 is secured to the base 110 of moving object 100 and is aligned along axis X4 which faces an exposed portion of magnet 232.

The moving assembly 100 provides an efficient way of driving four-wheels with two axes motion control. It also solves the limitation in the miniaturization of the system, as well as, the problem of having a single pinion to drive two gears into motion. In the configuration of moving object 100, one motor is provided for each of the two drivers 120 and 130. The two drivers 120 and 130 are diagonally arranged opposite each other. This allows the width of the base 110 to be narrower compared to a conventional configuration as shown in figure 1. One skilled in the art will recognise that other arrangement of both the two drivers 120 and 130 on the moving assembly 100 may be implemented without departing from the invention. When in use, the pinion 222 which is mounted on motor 160 or 170 drives the gear 251. Movement of gear 251 will cause pinion 235 to rotate and in turn causes gear 241 to rotate. Figure 12 shows the arrangement of pinion 222, gear 251, pinion 235 and gear 241.

Figure 19 shows a cross section of magnet 233. Magnet 233 is a conventional miniature axial magnet having a north pole 2331 and a south pole 2332. Magnet 233 is a

disk shape magnet. Lines 2334 illustrate the magnetic field of magnet 233. Magnet 233 has a longitudinal axis X5 running through the north and south poles.

Figure 20 illustrates a method of arranging magnet 233 to cavity 232a of magnet holder 232 where the axis X4 and axis X5 are in the same direction. In figure 20, cavity 232a is circular in shape in order to fit magnet 233. Direction 1900 shows the rotation of magnet holder 232. Lines 2334 illustrate the magnetic field of the magnet 233. As shown in figure 20, the magnetic fields are extending towards the sensing element 231 and out of the magnetic holder 232. This arrangement of magnet 233 to cavity 232a creates a large magnetic field which may interact with any nearby magnetic fields. This magnetic interference is undesirable and will interfere with other nearby magnetic fields from other magnetic encoders or DC motors in the vicinity.

Figure 21 illustrates an embodiment of this invention where the axis X5 of magnet 233 is arranged perpendicular to the axis X4 of magnetic holder 232. As shown in figure 21, the circular edge consisting of both north pole 2331 and south pole 2332 of the magnet 233 are exposed and facing the sensing element 231. This gives high concentration of magnetic field, shown as lines 2334, in the magnetic encoder. Magnetic fields away from the magnetic holder 232 in other directions are weak and therefore cause little cross magnetic interference to other nearby magnetic fields. This greatly improves and provides accurate feedback to the controller 180. Further, a feasible compact and miniature magnetic encoder feedback system with very low cross magnetic interference is achieved. One skilled in the art will recognise that the axis X5 of magnet 233 may also be arranged at an angle between 70° to 110° to the axis X4 of magnetic holder 232 without departing from the invention as long as a portion of both north and south poles are facing the sensing element 231.

A laboratory test was set up to test the magnetic encoder feedback system. A small motor with magnetic encoder feedback system was used in the test. 2 Volts power supply was used to drive the motor directly. In a first test, no magnet was used and the current measured was 71 mA. In a second test, a magnet was inserted as shown in figure 20 and the current measured was 84 mA. Notably, there was an increase of the current by 18.3%, caused by the magnetic interference between the motor and the magnet. As higher winding current in the motor will usually result in over-heating of the motor windings and subsequently lead to damage of the motors, the configuration as shown in figure 20 will typically damage or shorten the life span of the motor. In a third test, an axial magnet was used according to the arrangement as shown in figure 21. The current measured remained approximately at 71 mA (same as the case without any magnet attached), indicating that there was negligible magnetic interference.

Another test was carried out involving running of the moving object 100 with magnetic encoder feedback system at an extreme speed. With the arrangement as shown in figure 20, the maximum speed that the moving object 100 is capable of running is approximately 20% lower than that using the arrangement as shown in figure 21. All tests indicated that the arrangement as shown in figure 21 has superior performance over conventional arrangement as shown in figure 20.

20

The above is a description of exemplary embodiments of a magnetic encoder for a miniature two axes four-wheel drive control in accordance with this invention. It is foreseeable that those skilled in the art can and will design alternative systems based on this disclosure that infringe upon this invention as set forth in the following claims.

25

Claims:

1. A magnetic encoder for a miniature four-wheel driver control comprising:

a conventional disk shaped permanent axial magnet having a first end, a second
5 end and a continuous sidewall between said first end and second end, said disk shaped
permanent axial magnet is bisected between said first end and said second end such that
said continuous sidewall consists of a north pole and a south pole;

a magnet holder having a cavity to receive said disk shaped permanent magnet,
said cavity; and

10 a sensing element position apart from said magnet holder and facing an exposed
portion of said north and south poles of said disk shaped permanent axial magnet, wherein
said disk shaped permanent axial magnet has a longitudinal axis running through said first
end and said second end, said magnet holder and said sensing element share a
longitudinal axis that is perpendicular to said longitudinal axis of said disk shaped
15 permanent axial magnet.

2. A magnetic encoder for a miniature four-wheel driver control comprising:

a conventional disk shaped permanent axial magnet having a first end, a second
20 end and a continuous sidewall between said first end and second end, said disk shaped
permanent axial magnet is bisected between said first end and said second end such that
said continuous sidewall consists of a north pole and a south pole;

a magnet holder having a cavity to receive said disk shaped permanent magnet,
said cavity; and

25 a sensing element position apart from said magnet holder and facing an exposed
portion of said north and south poles of said disk shaped permanent axial magnet, wherein
said magnet holder and said sensing element share a longitudinal axis, and said permanent

axial magnet has a longitudinal axis running through said north pole and said south pole that is arranged at an angle between 70 to 110 degrees to said longitudinal axis of said magnet holder and said sensing element.

5 3. The magnetic encoder according to any of claims 1 and 2 wherein a portion of said cavity is adapted to mate with a portion of said permanent axial magnet.

4. A moving object comprising a base and a magnetic encoder according to any of claims 1-3, wherein said magnetic encoder is arranged on said base to monitor the
10 movement of the moving object.

5. A miniature two axes four-wheel drive control for an object comprising:
a base;
a first driver having:
15 a first wheel assembly;
a second wheel assembly;
a motor assembly for driving said second wheel assembly,
a magnetic encoder according to claim 1 or claim 2 arranged between said
first and second wheel assemblies; and
20 a frame for holding said first wheel assembly, said second wheel assembly,
said motor assembly, and said encoder assembly;
a second driver identical to said first driver; and
a controller for controlling a movement of said object, wherein in use, said motor
assembly drives said second wheel assembly which causes said encoder assembly to
25 cause said first wheel assembly to move.

6. The miniature two axes four-wheel drive control according to claim 5 wherein said frame comprises a pair of eyelets for securing said frame to said base.

7. The miniature two axes four-wheel drive control according to any of claims 5-6 wherein said first driver and said second driver are diagonally arranged apart from each other.