

METHOD AND APPARATUS FOR DETECTING ORIGIN OF PULSE MOTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 The present invention relates to a method of detecting a position of the origin which is a reference to an angular position of rotation of a pulse motor (stepping or stepper motor) and an origin detecting apparatus for detecting a position of the origin of a pulse motor using this method.

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2. Description of the Prior Art

 In order to accurately determine a stop position of an apparatus driven by a pulse motor, a commercially available pulse motor generally has means for indicating a position of rotation of the pulse motor, called a rotary encoder, attached thereto. This rotary encoder continuously generates an angle signal (a signal indicating an angular position of rotation of the pulse motor) during the output axis (rotatable axis) of the pulse motor rotates one revolution.

15 This rotary encoder is used to detect an angular position of revolution of the output axis of the pulse motor. However, such rotary encoder does not have a function to detect the origin of the output axis. Therefore, an origin detecting sensor for outputting one pulse at a predetermined position of origin during the output axis rotates one revolution is

20 mounted to the rotary encoder.

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 There are two types of the origin detecting sensors. One

is a type using an optical sensor and the other is a type using a magnetic sensor. Fig. 6 shows a structure of an example of a pulse motor having an origin detecting sensor in which an optical sensor is used. A sensor disk 3 is

5 coaxially mounted on a rear end portion of an output axis 2 of a pulse motor 1. The sensor disk 3 rotates simultaneously with the rotation of the output axis 2. A slit is formed on a predetermined position of the sensor disk 3 (usually in the proximity of the circumference of the disk 3) as a movable
10 element 4. A light transmission type sensor for detecting light which passes through the slit of the movable element 4 is provided as a fixed sensor 5 at a predetermined position where the light beam passing through the movable element 4 can be detected.

15 In the origin detecting sensor using an optical sensor as constructed above, when the pulse motor 1 is driven and its output axis 2 is rotated, the sensor disk 3 is rotated at the same time. Accordingly, the movable element 4 is also rotated together and passes through the position of the fixed
20 sensor 5, namely, a detection area 5A (see Fig. 7) of the sensor 5 once for every revolution of the output axis 2. Since the fixed sensor 5 detects, every time the movable element 4 passes through the detection area 5A of the fixed sensor 5, light transmitted through the movable element 4, a
25 detected signal has a pulse shape which is outputted from the fixed sensor 5. As a result, since the time point when the fixed sensor 5 generates the detection signal corresponds to

the position of the movable element 4, when the position of the movable element 4 is defined to be the origin, the origin in the rotating direction of the pulse motor 1 can be detected based on the detection signal outputted from the fixed sensor 5. Further, in the case of an origin detecting sensor using a magnetic sensor, a permanent magnet having N-S poles is used as a movable element and a magnetic sensitive element such as a Hall element, for example, is used as a fixed sensor.

10 In the origin detecting sensor as arranged above, in case the fixed sensor 5 is located at a position which conforms with the stop position of the movable element 4, when the sensor 5 detects the movable element 4, i.e., the origin is detected, light is transmitted to the fixed sensor 5 through the movable element 4, as shown in Fig. 7A. Therefore, an origin detection signal PJ having, for example, logical "1" is continuously outputted from the fixed sensor 5 as shown in Fig. 7B. Also, in the case of the magnetic sensor, an origin detection signal of logical "1" can similarly be outputted continuously when the movable element stops at a position facing the magnetic sensitive element.

However, since a rotation angle $\Delta\theta$ of one step of the pulse motor 1 is small, it is very difficult to conform the stop position of the movable element 4 with the fixed position of the fixed sensor 5. In addition, even if the fixed position of the fixed sensor 5 conforms with the stop position of the movable element 4 in case the pulse motor 1

has no load imposed thereon, the stop position of the movable element 4 can be shifted when a mechanical load is imposed on the pulse motor 1, and hence the position of the fixed sensor 5 may not conform with the position of the movable element 4 in the stop state.

Consequently, in general, there are many cases the stop position of the movable element 4 does not conform with the fixed position of the fixed sensor 5. Therefore, as shown in Fig. 8A, the stop position of the movable element 4 is often situated midway in the range of a rotation angle corresponding to one step movement of the pulse motor 1. Accordingly, a detection signal regarding the movable element (detection of movable element signal) outputted from the fixed sensor 5 becomes a pulse signal PP, as shown in Fig. 8B, which has a narrow pulse width obtained every time the movable element 4 passes through the detection area 5A of the fixed sensor 5. Therefore, in the prior art, the pulse signal PP is supplied to a latch circuit which inverts its output by application of the pulse signal PP so that a continuous origin detection signal PJ as shown in Fig. 8C can be obtained.

However, there occurs a disadvantage as explained below in case a latch circuit is used. That is, as shown in Fig. 9, there can be produced what is called an overshoot OB in which the pulse motor 1 overruns the stop position and go backward to stop at the stop position depending on a load imposed thereon. Therefore, the pulse motor 1 may stop after

swinging back and forth the stop position. In this case, when the movable element 4 transmits a slight amount of light to the fixed sensor 5 or supplies a slight amount of magnetic field to the magnetic sensor by the overrun and returns to the stop position again due to the overshoot OB, a pulse signal PP having a narrow pulse width is outputted from the fixed sensor 5 due to the overshoot OB. As a result, the latch circuit is triggered by the pulse signal PP and the output thereof is inverted so that a continuous origin detection signal PJ is outputted at a position of rotation angle θ_0 (the stop position).

On the other hand, even in the same pulse motor, the amount of an overshoot OB can vary depending on the magnitude of a load, and the like. For example, when the amount of an overshoot OB is smaller than that in Fig. 9, a pulse signal PP having a narrow pulse width is not outputted from the fixed sensor 5 at the position of rotation angle θ_0 as in the case of Fig. 9, and hence the latch circuit is not inverted in its output. In this case, as shown in Fig. 10, a pulse signal PP having a narrow pulse width is outputted from the fixed sensor 5 at a position of rotation angle θ_1 which is a different from the angle position in Fig. 9 and a continuous origin detection signal PJ is outputted at that angle position θ_1 . Consequently, an important disadvantage occurs that the detected origin positions differ from each other even in the same pulse motor. In addition, as shown in Fig. 11, when the amount of an overshoot OB is equal to or larger

than the rotation angle range corresponding to two step
movement of the pulse motor, there is a disadvantage that the
detected origin position ST may be a position which is spaced
apart from the true origin position by a distance equal to or
5 more than two step movement of the pulse motor.

SUMMARY OF THE INVENTION

A first object of the present invention is to provide a
method of detecting the origin of a pulse motor using a latch
10 circuit, by which a predetermined angular position of
revolution of the pulse motor can always be defined to be the
origin of the pulse motor even if the magnitude of an
overshoot at a pause position of the pulse motor fluctuates.

A second object of the present invention is to provide a
15 pulse motor origin detecting apparatus using the above pulse
motor origin detecting method and utilizing a latch circuit
to generate a continuous origin detection signal, wherein a
predetermined angular position of revolution of the pulse
motor can always be defined to be the origin of the pulse
20 motor even if the magnitude of an overshoot at a pause
position of the pulse motor fluctuates.

A third object of the present invention is to provide a
method of detecting the origin of a pulse motor, by which a
predetermined angular position of revolution of the pulse
25 motor can always be defined to be the origin of the pulse
motor even if the magnitude of an overshoot at a pause
position of the pulse motor fluctuates more than the amount

corresponding to the angular movement of two steps of the pulse motor.

A fourth object of the present invention is to provide a pulse motor origin detecting apparatus using the above pulse motor origin detecting method, wherein a predetermined angular position of revolution of the pulse motor can always be defined to be the origin of the pulse motor even if the magnitude of an overshoot at a pause position of the pulse motor fluctuates more than the amount corresponding to the angular movement of two steps of the pulse motor.

According to the first aspect of the present invention, there is provided a method of detecting the origin to an angular position of rotation of the rotatable output axis of a pulse motor using a movable element for use in detection of a position mounted to the rotatable output axis of the pulse motor, a fixed sensor for detecting the passage of the movable element and outputting a detection signal in response thereto, and a latch circuit whose output is inverted when triggered by a detection signal from the fixed sensor, which comprises the steps of: supplying a reversing pulse for rotating the pulse motor in the reverse direction to the pulse motor in case no detection signal is outputted from the fixed sensor when the pulse motor stops after a detection signal has been outputted from the fixed sensor; determining to be the normal origin, when the fixed sensor outputs a detection signal again during the reverse revolution of the pulse motor on supplying the reversing

pulse to the pulse motor, a pause position where the pulse motor stops after having rotated in the reverse direction; and supplying again an advancing pulse for rotating the pulse motor in the normal direction, when the fixed sensor outputs
5 no detection signal during the reverse revolution of the pulse motor on supplying the reversing pulse to the pulse motor, and determining to be the normal origin a pause position where the pulse motor stops after having rotated in the normal direction by one step.

10 According to the second aspect of the present invention, there is provided a pulse motor origin detecting apparatus which comprises: a movable element for use in detection of a position mounted to the rotatable output axis of a pulse motor; a fixed sensor for detecting the passage of the
15 movable element and outputting a detection signal in response thereto; a latch circuit whose output is inverted when the latch circuit is triggered by a detection signal from the fixed sensor in the state that the pulse motor is rotating in the normal direction; stop control means for stopping the
20 normal revolution of the pulse motor when the output of the latch circuit is in the inverted state; a reversing pulse generator for generating a reversing pulse for rotating the pulse motor in the reverse direction by a predetermined number of step when the pulse motor is stopped by the stop
25 control means and a pause position of the movable element stopped with the stop of the pulse motor does not conform with the position of the fixed sensor; an advancing pulse

generator for supplying again an advancing pulse for rotating
the pulse motor in the normal direction to the pulse motor
when no detection signal is generated from the fixed sensor
in the state that the pulse motor has been rotated in the
5 reverse direction by the reversing pulse from the reversing
pulse generator; and a controller for determining, in the
state that the output of the latch circuit is inverted, to be
the normal origin, in case a detection signal is outputted
from the fixed sensor when the pulse motor is stopped by the
10 stop control means, a pause position where the pulse motor is
stopped, and in case no detection signal is outputted from
the fixed sensor when the pulse motor is stopped, to be the
normal origin, when a detection signal is outputted from the
fixed sensor in the state that the pulse motor has been
15 rotated in the reverse direction by the reversing pulse from
the reversing pulse generator, a pause position where the
pulse motor stops after its reverse revolution, and when no
detection signal is outputted from the fixed sensor in the
state that the pulse motor has been rotated in the reverse
20 direction, a pause position where the pulse motor stops after
having rotated in the normal direction by the advancing pulse
from the advancing pulse generator from the pause position of
the pulse motor having rotated in the reverse direction.

In accordance with the origin detecting method according
25 to the first aspect of the present invention and the origin
detecting apparatus according to the second aspect of the
present invention, in either case where an overshoot occurs

on a movement of the rotatable output axis of the pulse motor and an origin position is detected by this overshoot, or an origin position is detected when the pulse motor is rotated in step by step, the same detected position can be determined
5 to be the position of the of the pulse motor. Therefore, according to the present invention, in ether state where a load fluctuates whereby an overshoot occurs on a movement of the rotatable output axis of the pulse motor or where an overshoot does not occur, there is obtained an advantage that
10 a pause position where the load driven by the pulse motor stops can accurately be defined to be the same position.

According to the third aspect of the present invention, there is provided a method of detecting an origin to an angular position of rotation of the rotatable output axis of
15 a pulse motor using a movable element for use in detection of a position mounted to the rotatable output axis of the pulse motor, a fixed sensor for detecting the passage of the movable element and outputting a detection signal in response thereto, and a latch circuit whose output is inverted when
20 triggered by a detection signal from the fixed sensor, which comprises the steps of: supplying an advancing pulse for rotating the pulse motor in the normal direction to the pulse motor; detecting the inversion of the output of the latch circuit caused by a detection signal outputted from the fixed
25 sensor each time the movable element passes through the position of the fixed sensor during the normal revolution of the pulse motor; and controlling to stop the pulse motor when

the inversion of the output of the latch circuit is detected,
and the step of controlling further comprises, in case a
pause position of the movable element does not conform with
the position of the fixed sensor, the steps of: returning the
5 angular position of rotation of the pulse motor back to a
retreat position which is subjected to no effect of an
overshoot by rotating the pulse motor in the reverse
direction; increasing the number of steps of revolution of
the pulse motor in the normal direction by one step than that
10 of the pulse motor in the reverse direction when rotating the
pulse motor again in the normal direction from the retreat
position; and repeating the reverse revolution of the pulse
motor to the retreat position followed by the normal
revolution of the pulse motor from the retreat position with
15 the number of steps increased by one step than that of the
reverse revolution until a detection signal is outputted from
the fixed sensor when the pulse motor is returned back to the
retreat position.

According to the fourth aspect of the present invention,
20 there is provided a pulse motor origin detecting apparatus
which comprises: a movable element for use in detection of a
position mounted to the rotatable output axis of a pulse
motor; a fixed sensor for detecting the passage of the
movable element and outputting a detection signal in response
25 thereto; a latch circuit whose output is inverted when the
latch circuit is triggered by a detection signal from the
fixed sensor in the state that the pulse motor is rotating in

the normal direction; stop control means for stopping the normal revolution of the pulse motor when the output of the latch circuit is in the inverted state; a reversing pulse generator for applying a reversing pulse for returning the angular position of rotation of the pulse motor back to a retreat position which is subjected to no effect of an overshoot by rotating the pulse motor in the reverse direction by N steps in case the pulse motor is stopped by the stop control means and a pause position of the movable element stopped with the stop of the pulse motor does not conform with the position of the fixed sensor; an advancing pulse generator for applying to the pulse motor an advancing pulse for rotating the pulse motor in the normal direction by the reverse revolution steps N plus one step, namely, $(N+1)$ steps in case no detection signal is generated from the fixed sensor when the angular position of rotation of the pulse motor is returned back to the retreat position by the reversing pulse from the reversing pulse generator; and a controller for determining, in the state that the output of the latch circuit is inverted, to be the normal origin, in case a detection signal is outputted from the fixed sensor when the pulse motor is stopped by the stop control means, a pause position where the pulse motor is stopped, and for returning the angular position of rotation of the pulse motor back to the retreat position, in case the pulse motor is stopped and a pause position of the movable element does not conform with the position of the fixed sensor, by rotating

the pulse motor in the reverse direction by N steps by the reversing pulse from the reversing pulse generator, the controller determining to be the normal origin, when a detection signal is outputted from the fixed sensor in the state that the pulse motor has been rotated in the reverse direction, a pause position where the pulse motor stops after having rotated in the normal direction by (N-1) steps from the retreat position after its reverse revolution, and supplying to the reversing pulse generator an instruction for causing the reversing pulse generator to generate the reversing pulse when no detection signal is outputted from the fixed sensor in the state that the pulse motor has been rotated in the reverse direction.

In accordance with the origin detecting method according to the third aspect of the present invention, and the origin detecting apparatus according to the fourth aspect of the present invention, a predetermined angular position of revolution of the pulse motor can always be detected as the origin of the pulse motor even if the magnitude of an overshoot at a pause position of the pulse motor fluctuates more than the amount corresponding to the angular movement of several steps of the pulse motor

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A and 1B are waveforms for explaining the first embodiment of the pulse motor origin detecting method according to the present invention;

Fig. 2 is a waveform for explaining the detecting operation of an origin detecting sensor attached to the pulse motor;

Fig. 3 is a block diagram showing the first embodiment of the pulse motor origin detecting apparatus according to the present invention;

Fig. 4 is a waveform for explaining the second embodiment of the pulse motor origin detecting method according to the present invention;

Fig. 5 is a flow chart for briefly explaining one example of a program required to construct a pulse motor origin detecting apparatus which implements the second embodiment of the pulse motor origin detecting method according to the present invention;

Fig. 6 is a partly sectional side view for explaining the structure of an example of the pulse motor to which an origin detecting sensor is attached;

Fig. 7 is a waveform for explaining an example of the operation of detecting an origin of the pulse motor in accordance with a prior pulse motor origin detecting method;

Fig. 8 is a waveform similar to Fig. 7 for explaining another example of the operation of detecting an origin of the pulse motor in accordance with a prior pulse motor origin detecting method;

Fig. 9 is a waveform for explaining an example of the disadvantage in prior pulse motor origin detecting method;

Fig. 10 is a waveform similar to Fig. 9 for explaining

another example of the disadvantage in prior pulse motor origin detecting method; and

Fig. 11 a waveform for explaining still further example of the disadvantage in prior pulse motor origin detecting method.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now the preferred embodiments of the present invention will be explained in detail with reference to the accompanying drawings.

First, a first embodiment of a pulse motor origin detecting method according to the present invention will be explained referring to Figs. 1 and 2. Figs. 1A and 1B are wave form diagrams showing operation modes characterized by the pulse motor origin detecting method of the first embodiment. Fig. 2 is a wave form diagram showing a state of an origin detecting operation of the pulse motor 1 in the pulse motor 1 to which the origin detecting sensor explained referring to Fig. 6 is added when the pulse motor 1 is manufactured such that the stop position of the movable element 4 of the sensor disk 3 matches the installation position of the fixed sensor 5. When the stop position of the movable element 4 matches the installation position of the fixed sensor 5, an apparatus of prior art also operates normally as explained referring to Fig. 7.

In the case of the pulse motor in which the stop position of the movable element 4 matches the installation position of

the fixed sensor 5, as shown in Fig. 2, the fixed sensor 5 detects a transmitted light beam first at a rising edge portion of an overshoot based on the overshoot at the stop position of the pulse motor 1 and outputs a pulse signal PP having narrow pulse width. Then, the fixed sensor 5 detects a transmitted light beam at a falling edge portion of the overshoot and outputs a pulse signal PP having narrow pulse width. And then, since the fixed sensor 5 continuously detects a transmitted light beam at an end point of the overshoot, an output of the fixed sensor 5 becomes a detection signal of continuous logical 1 (H). Therefore, the output of the latch circuit is inverted at the rising edge portion of the overshoot and is inverted again at the falling edge portion of the overshoot, and then is further inverted at the end point of the overshoot. As a result, as shown in Fig. 2, an output of continuous logical H following a short pulse is obtained from the latch circuit. Consequently, in this case, the stop position of the pulse motor 1 is judged as an origin position ST.

On the other hand, in the case where the pulse motor 1 is manufactured such that the stop position of the movable element 4 does not match the installation position of the fixed sensor 5, even if the stop position of the pulse motor is the same position before the detection area 5A of the fixed sensor 5, detection signals outputted from the fixed sensor 5 are different dependent on magnitude of an overshoot amount, and thus, a detection of an origin position ST of the

rotation angle of the pulse motor 1 is difficult. Such examples will be explained referring to Figs. 1A and 1B.

Fig. 1A shows an example where an overshoot amount is large at the stop position of step 4 of the pulse motor 1 which is one step before the detection area 5A of the fixed sensor 5. In this case, the fixed sensor 5 detects first a transmitted light beam at a rising edge portion of an overshoot and outputs a pulse signal PP having narrow pulse width. Then, the fixed sensor 5 detects a transmitted light beam at a falling edge portion the overshoot and outputs a pulse signal having narrow pulse width. And then, since the fixed sensor 5 does not detect a transmitted light beam at the end point of the overshoot, no detection signal is outputted from the fixed sensor 5. Therefore, the output of the latch circuit is only inverted at the rising edge portion of the overshoot and is inverted again at the falling edge portion of the overshoot. Thus, as shown in Fig. 1A, a single short pulse is outputted from the latch circuit. As a result, the step position where the pulse motor stops before the detection area 5A is possibly judged as an origin position ST.

Fig. 1B shows an example where an overshoot amount is small at the stop position of step 4 of the pulse motor 1 which is one step before the detection area 5A of the fixed sensor 5 but is large at the stop position of next step 5. In this case, since the fixed sensor 5 does not detect a transmitted light beam at step 4 position where the pulse

motor 1 stops before the detection area 5A, no detection signal is outputted at all from the fixed sensor 5.

Therefore, there is no danger that the stop position of step 4 is judged as an origin position ST. However, since an

5 overshoot amount is large at the stop position of next step 5, the fixed sensor 5 detects first a transmitted light beam at a rising edge portion of the overshoot and outputs a pulse signal PP having narrow pulse width. Then, the fixed sensor 5 detects a transmitted light beam at a falling edge portion
10 of the overshoot and outputs a pulse signal PP having narrow pulse width. Further, the fixed sensor 5 detects a

transmitted light beam at a next rising edge portion of the overshoot and outputs a pulse signal having narrow pulse width. And then, since the fixed sensor 5 does not detect a
15 transmitted light beam at an end point of the overshoot, no detection signal is outputted from the fixed sensor 5.

Consequently, the output of the latch circuit is inverted at the rising edge portion of the overshoot and is inverted again at the falling edge portion of the overshoot and

20 further, the output of the latch circuit is inverted at the next rising edge portion of the overshoot. As a result, a short pulse is outputted from the latch circuit and then, a continuous detection signal of logical H is outputted from the latch circuit. Since this continuous detection signal of
25 logical H is same as an origin detection signal PJ, the step 5 position where the pulse motor stops may be judged as the origin position ST with large possibility.

In the first embodiment of the present invention, as shown in Figs. 1A and 1B, when a detection signal of the fixed sensor 5 becomes logical 0 (L) at an end point of an overshoot even if an output of the latch circuit is inverted and becomes logical H, a reversing pulse for rotating the pulse motor in the reverse direction is supplied to the pulse motor 1. When the pulse motor is rotated by one step in the reverse direction by the supply of the reversing pulse, no detection signal is outputted from the fixed sensor 5 in the example of Fig. 1A. That is, the output of the fixed sensor 5 is not changed. When the output of the fixed sensor 5 is not changed, an advancing pulse for rotating the pulse motor in the normal direction is supplied to the pulse motor 1. The step position where the pulse motor 1 stops after one step rotation in the normal direction based on the advancing pulse is judged as the origin position ST.

Further, in the example shown in Fig. 1B, when the pulse motor is rotated by one step in the reverse direction by supplying a reversing pulse to the pulse motor 1, the fixed sensor 5 detects a passage of the movable element 4 and a pulse signal PP having narrow pulse width is outputted from the fixed sensor 5. That is, the output of the fixed sensor 5 is changed. When the output of the fixed sensor 5 is changed, the stop step position after one step rotation in the reverse direction by the reversing pulse is judged as the origin position ST.

As described above, according to the origin detecting

method of the first embodiment of the present invention, the same step position 4 can be judged as the origin position ST in either case where, as shown in Fig. 1A, the output of the latch circuit is inverted by an overshoot at the stop

5 position of step 4 which is before the detection area 5A of the pulse motor or where, as shown in Fig. 1B, the output of the latch circuit is inverted during the rotation in step 5 of the pulse motor. Therefore, when the pulse motor is manufactured such that the stop position of the movable
10 element 4 does not match the position of the fixed sensor 5, the same step position can be judged as the origin position ST in either case where an overshoot amount becomes large due to a light load and the output of the latch circuit is inverted at the stop position before the detection area, or
15 where an overshoot amount becomes small due to a heavy load and the output of the latch circuit is inverted during the rotation step passing through the detection area. As a result, the stop position of the pulse motor is not shifted.

Fig. 3 shows an embodiment of the pulse motor origin
20 detecting apparatus according to the present invention. Further, in Fig. 3, since the pulse motor 1 has the same configuration as that shown in Fig. 6, the same reference numerals are assigned to the corresponding portions and the explanation of those portions will be omitted.

25 A detection signal of the fixed sensor 5 is inputted to a latch circuit 5 and to an input port 11D of the origin detecting apparatus 10 according to the present invention.

An output of the latch circuit 6 is also inputted to the input port 11D of the origin detecting apparatus 10. In this embodiment, the origin detecting apparatus 10 comprises a controller 11, an advancing pulse generator 12 and a reversing pulse generator 13 controlled by the controller 11, and an assembling circuit 14 for assembling the outputs of the advancing pulse generator 12 and the reversing pulse generator 13 and for supplying the assembled signal to the pulse motor 1.

10 The controller 11 can be made up of a generally known one chip microcomputer. The one chip microcomputer shown in the figure comprises a central processing unit 11A, a RAM 11B utilized for temporarily storing the number of pulses supplied to the pulse motor 1, an output status of the latch circuit 6 and a presence/absence of an output of the fixed sensor 5 etc., a ROM 11C in which a program for driving the controller 11 to work as an origin detecting apparatus is stored, the input port 11D, and an output port 11E.

20 As mentioned above, a detection signal of the fixed sensor 5 and an output signal of the latch circuit 6 are inputted to the input port 11D of the controller 11. The central processing unit 11A always monitors the output states of the latch circuit 6 and the fixed sensor 5. When the output of the latch circuit 6 is inverted, for example, to logical H (logical 1), the operation of the advancing pulse generator 12 is stopped to stop the generation of an advancing pulse. At the same time, a logical state of the

fixed sensor 5 is read out and is stored in the RAM 11B.

This reading is performed in the timing when the movement of the output axis 2 of the pulse motor 1 is considered to be stopped rather than the timing when the rotation of the

5 output axis 2 of the pulse motor 1 is swinging due to an overshoot. When the output of the latch circuit 6 is held to logical H and when the output of the fixed sensor 5 is also logical H, a step position where the pulse motor is currently stopped is judged as the origin position ST. That is, when
10 the movable element 4 stays in the detection area 5A of the fixed sensor 5, the position is judged as the origin position ST.

On the other hand, when the output of the fixed sensor 5 is logical L (logical 0) although the output of the latch
15 circuit 6 is logical H, the central processing unit 11A supplies a control signal for outputting a reversing pulse to the reversing pulse generator 13 via the output port 11E. The reversing pulse generator 13 supplies a reversing pulse to the pulse motor 1 to rotate the output axis 2 by one pulse
20 rotation in the reverse direction. The central processing unit 11A monitors, after commanding the generation of a reversing pulse, as to whether or not an output is generated from the fixed sensor 5.

When the output of the fixed sensor 5 is not changed, as
25 shown in Fig. 1A, the central processing unit 11A supplies a control signal for outputting an advancing pulse to the advancing pulse generator 12 via the output port 11E and an

advancing pulse generated from the advancing pulse generator 12 is supplied to the pulse motor 1 to rotate the output axis 2 by one pulse rotation in the normal direction. Then the stopped step position is judged to be the origin position ST.

5 On the other hand, as shown in Fig. 1B, when the output of the fixed sensor 5 is changed after the reversing pulse is supplied to the pulse motor 1, the step position where the pulse motor 1 is stopped after reverse rotation by the reversing pulse is judged to be the origin position ST.

10 Further, when an advancing pulse is supplied again to the pulse motor 1 to rotate it by one pulse rotation in the normal direction and the pulse motor 1 returns to the original position, as shown in Fig. 1A, a detection signal is generated again from the fixed sensor 5 by an overshoot OB
15 and the output of the latch circuit 6 is inverted by this detection signal. However, since this inverting operation is generated as a result of the detection of the origin position ST, the inverted state of the latch circuit 6 is maintained.

Also, as shown by dotted lines in Figs. 1A and 1B, the
20 apparatus can be arranged such that two or three reversing pulses are supplied to the pulse motor 1 to move the load toward reverse direction enough, and then advancing pulses are supplied to the pulse motor 1 to stop it at the normal origin position ST. In such a way, when the apparatus is
25 arranged such that the load is moved toward reverse direction enough and then advancing pulses are supplied to the pulse motor 1 to stop it at the regular origin position, an

influence of backlash can be eliminated.

Further, in the embodiment shown in Fig. 3, the latch circuit 6 is provided externally to the origin detecting apparatus 10. However, the latch circuit operation can also
5 be performed using a memory cell portion of the RAM 11B provided in the controller 11.

Fig. 4 is a wave form diagram for explaining a second embodiment of the pulse motor origin detecting apparatus according to the present invention. In the wave form diagram
10 of Fig. 4, the wave form after time T_A should have been drawn in shape of stairs but drawn in a step shape. Numerals (like in a scale) in the figure indicate step numbers. The second embodiment provides a pulse motor origin detecting method wherein a prescribed rotation angle position can always be
15 detected even if magnitude of an overshoot generated by the pulse motor 1 is as large as a rotation amount of several steps of the pulse motor 1.

Specifically, when magnitude of an overshoot OB at a stop position of the pulse motor 1 is, as shown in Fig. 11, larger
20 than an amount of one step rotation, for example, amplitude of two step rotation, there is a danger in the pulse motor origin detecting method of the first embodiment that a position apart equal to or more than two steps from the origin position is judged as the origin position.

25 Therefore, in the pulse motor origin detecting method of the second embodiment, the latch circuit 6 is checked to see if the output is inverted for every one step rotation of the

pulse motor 1 in the normal direction. When the output of the latch circuit 6 is inverted, the advancing pulse generator 12 is inhibited to supply an advancing pulse to the pulse motor 1. As an example, when the movable element 4
5 provided on the sensor disk 3 enters the detection area 5A of the fixed sensor 5, a detection signal is outputted from the fixed sensor 5, and thus the output of the latch circuit 6 is inverted. In the second embodiment, when the output of the latch circuit 6 is inverted, the supply of an advancing pulse
10 to the pulse motor 1 is stopped, and thus the pulse motor 1 is stopped.

Then, in the state where the pulse motor 1 is stopped, the movable element 4 is checked to see if it has stopped in the detection area 5A of the fixed sensor 5. In this
15 example, as shown in Fig. 4, the movable element 4 enters the detection area 5A of the fixed sensor 5 by an overshoot. Therefore, the position of the movable element 4 never stops in the detection area 5A of the fixed sensor 5. Consequently, in this case, the pulse motor 1 is controlled
20 to make a reverse rotation up to a rotation angle position A where an influence of an overshoot is fully eliminated. The rotation angle position A where the pulse motor 1 stops after the reverse rotation is referred to as a retreat position A hereinafter. The retreat position A is a position where the
25 position of the movable element 4 does not reach the detection area 5A of the fixed sensor 5 by an overshoot OB when the pulse motor 1 rotates in either normal direction or

reverse direction from the retreat position. Fig. 4 shows an example where a position to which the pulse motor 1 is reversed by N ($N=3$ in this example) step rotation from the first stop position of the pulse motor 1 is defined as the retreat position A.

Then, after the reverse rotation of the pulse motor 1 to the rotation angle position of the retreat position A, the pulse motor 1 is rotated in the normal direction by $N+1$ ($N+1=4$ in this example) step rotation (compulsorily ignoring an overshoot) and is stopped. At this time, if the position of the movable element 4 is not in the detection area 5A of the fixed sensor 5, the pulse motor 1 is rotated in the reverse direction by $N+1$ step rotation to return the pulse motor 1 to the retreat position A. On the way back to the retreat position A, if the output of the fixed sensor 5 is not changed, then the pulse motor 1 is rotated again in the normal direction by $N+2$ step rotation this time from the retreat position A.

In such a way, in the second embodiment, when the pulse motor 1 is rotated again in the normal direction after the rotation angle position of the pulse motor 1 is returned to the retreat position A, the number of rotation steps in the normal direction is increased by +1 every time. By this operation, even if the magnitude of an overshoot OB is two step rotation or more, the position of the movable element 4 can be approached gradually to the detection area 5A of the fixed sensor 5. As a result, in the case of the pulse motor

1 which is manufactured such that the stop position of the
movable element 4 does not match the detection area 5A of the
fixed sensor 5, the pulse motor 1 is driven without fail to
stop at the stop position just after the movable element 4
5 passes through the detection area 5A.

When the movable element 4 stops at the stop position
just after it passes through the detection area 5A, the
movable element 4 passes through the detection area 5A
without fail on the way back to the retreat position A from
10 the stop position. At this time, since the fixed sensor 5
detects a transmitted light beam, a detection signal is
outputted from the fixed sensor 5. That is, the output of
the fixed sensor 5 is changed. Based on this output change,
the output of the latch circuit 6 is inverted. Consequently,
15 when the pulse motor 1 is rotated again in the normal
direction next from the retreat position A, the pulse motor 1
is rotated by $(N+2)-1$ step rotation in the normal direction.
Then, the stop position is determined as the origin position
ST of the rotation angle position of the pulse motor 1.

20 When the origin position ST is determined in such a way,
even if magnitude of an overshoot OB is equal to or greater
than two step rotation of the rotation angle step of the
pulse motor 1, the detected origin position is within one
step range from the detection area 5A without an exception.
25 In addition, even if magnitude of an overshoot OB fluctuates
due to the load fluctuation, the detected origin position is
not changed.

Fig. 5 is a flow chart for roughly explaining an example of a program required to operate the origin detecting apparatus when the origin detecting apparatus for implementing the pulse motor origin detecting method of the second embodiment explained referring to Fig. 4 is arranged. In Fig. 5, steps SP₁ and SP₂ compose a routine for moving an object to be controlled by supplying an advancing pulse to the pulse motor 1. That is, the advancing pulses are supplied to the pulse motor 1 one at a time. Every time an advancing pulse is supplied to the pulse motor 1, the output state of the latch circuit 6 (Fig. 3) is monitored. The advancing pulses are supplied to the pulse motor 1 until the output of the latch circuit 6 is inverted.

When it is detected that the output of the latch circuit 6 is inverted in step SP₂, the process moves to step SP₃. In step SP₃, at the stop position of the pulse motor 1, the movable element (slit) 4 is checked to see if it is in the detection area 5A of the fixed sensor 5. When the movable element 4 is in the detection area 5A of the fixed sensor 5, the process moves to step SP₄ and the stop position is determined as the origin position ST. Further, in order to simplify the expression on the drawing, the process of the judging block of step SP₂ is expressed as A, the process of the judging block of step SP₃ is expressed as B and the process of the judging block of step SP₃ is expressed as C in Fig. 5.

On the other hand, when the movable element 4 is not in

the detection area 5A, the process moves to step SP₅ and for example, three reversing pulses for rotating the pulse motor 1 in the reverse direction to the retreat position at which the detection signal is not influenced by an overshoot are generated from the reversing pulse generator 13 (refer to Fig. 3). Then, in step SP₆, the state of the latch circuit 6 is monitored to see if the state of the fixed sensor 5 is changed and if the state of the latch circuit 6 is inverted again during the reverse rotation of the pulse motor 1. When the state of the latch circuit 6 is inverted, the process moves to step SP₇. Then, a command is supplied to the advancing pulse generator 12 (refer to Fig. 3) to generate two ($3-1=2$) advancing pulses the number of which is less than the number of reversing pulses "3" by one and the pulse motor 1 is rotated by two step rotation in the normal direction. Then, in step SP₈, the stop position is judged as the origin position ST.

On the other hand, when the state of the latch circuit 6 is not changed during the reverse rotation of the pulse motor 1, the process moves to step SP₉. In step SP₉, four ($3+1=4$) advancing pulses the number of which is more than the number of the reversing pulses "3" by one are generated from the advancing pulse generator 12. Then, in step SP₁₀, the state of the latch circuit 6 is monitored to see if the state of the fixed sensor 5 is changed and if the state of the latch circuit 6 is inverted during the normal rotation of the pulse motor 1 by the four advancing pulses. When it is detected

that the output state of the latch circuit 6 is inverted, the process moves to step SP₁₁. In step SP₁₁, at the stop position of the pulse motor 1, the movable element 4 is checked to see if it is in the detection area 5A. When the
5 movable element 4 is in the detection area 5A, the process moves to step SP₁₂ and the stop position is judged as the origin position ST.

On the contrary, when it is detected that the state of the latch circuit 6 is not inverted in step SP₁₀, the process
10 moves to step SP₁₃ and five reversing pulses are supplied to the pulse motor 1, and then the process returns to the initial routine. That is, when the state of the latch circuit 6 is not changed although four ($3+1=4$) advancing pulses are supplied to the pulse motor 1 in step SP₉, it is
15 judged that some failure operation has occurred and an operation to return to the initial state is performed.

On the other hand, when it is judged that the position of the movable element 4 is not in the range of the detection area 5A in step SP₁₁, the process moves to step SP₁₄ and four
20 ($3+1=4$) reversing pulses are supplied to the pulse motor 1 so that the pulse motor 1 reaches the retreat position. The latch circuit 6 is checked in step SP₁₅ to see if the state of the latch circuit 6 is changed during the reverse rotation. When it is judged that the state of the latch circuit 6 is
25 changed during the reverse rotation, the process moves to step SP₁₆. In step SP₁₆, three ($4-1=3$) advancing pulses the number of which is less than the number of reversing pulses

"4" by one are supplied to the pulse motor 1 to rotate the pulse motor 1 by three step rotation in the normal direction. And thus, the stop position is judged as the origin position ST in step SP₁₇.

5 On the contrary, when the state of the latch circuit 6 is not inverted during the reverse rotation, the process moves to step SP₁₈ and five ($4+1=5$) advancing pulses the number of which is more than the number of the reversing pulses by one are generated from the advancing pulse generator 12 to rotate
10 the pulse motor 1 by five step rotation in the normal direction. In step SP₁₉, the state of the latch circuit 6 is monitored during the normal rotation to see if the state of the latch circuit 6 is inverted during the five step normal rotation. When the state of the latch circuit 6 is inverted,
15 the process moves to step SP₂₀. When the movable element 4 is in the range of the detection area 5A at the stop position, the stop position is judged as the origin position ST in step SP₂₁.

20 In step SP₁₉, when the state of the latch circuit 6 is not inverted during the five step normal rotation of the pulse motor 1, it is judged that some failure operation has occurred similarly to the case of step SP₁₉ and six reversing pulses are generated in step SP₂₂, and then the process returns to the initial routine.

25 In step SP₂₀, when it is judged that the position of the movable element 4 is not in the range of the detection area 5A, the process moves to step S₂₃ and five reversing pulses

for rotating the pulse motor 1 in the reverse direction up to the retreat position again are generated from the reversing pulse generator 13. When it is detected in step SP₂₄ that the output state of the latch circuit 6 is changed during the
5 reverse rotation by the five reversing pulses, four ($5-1=4$) advancing pulses the number of which is less than the number of reversing pulses by one are generated from the advancing pulse generator 12 in step SP₂₅ and the stop position of the pulse motor 1 after the normal rotation by the advancing
10 pulses is judged as the origin position ST in step SP₂₆.

Similarly, after this, by providing a control routine and by repeatedly performing a reverse rotation of the pulse motor 1 to the retreat position and a normal rotation whose number of steps is more than that of the reverse rotation by
15 one, an origin position of the pulse motor 1 can accurately be prescribed to a same position even if magnitude of an overshoot is several step rotation. However, in this case, an example where magnitude of an overshoot is in the degree of two steps is discussed. Therefore, the objects can be
20 achieved practically by the routines SP₂₃, SP₂₄ and SP₂₅.

Thus, by incorporating the program shown in Fig. 5 into the ROM 11C shown in Fig. 3, the origin detecting apparatus of the second embodiment for implementing the origin detecting method of the second embodiment can be arranged.

25 As explained above, according to the present invention, in a mechanical control system controlled by a pulse motor, even if an overshoot occurs at a stop time of the pulse

motor, a constant rotation angle position can always be detected as an origin position and the pulse motor can be stopped at the origin position. Particularly, according to the second origin detecting method, even if magnitude of an overshoot corresponds to a rotation amount equal to or greater than two steps, the pulse motor can be stopped at a regular origin position. In addition, even if a load of the mechanical system fluctuates and magnitude of an overshoot fluctuates, a same rotation angle position can be detected as an origin position. Therefore, an origin position where the pulse motor stops is not varied. In this point, when the method and the apparatus of the present invention are applied to a semiconductor integrated circuit device (IC) transporting apparatus and to an IC positioning apparatus etc., the effect is very large.

WHAT IS CLAIMED IS:

1. A method of detecting the origin to an angular position of rotation of the rotatable output axis of a pulse motor using a movable element for use in detection of a position mounted to the rotatable output axis of said pulse motor, a fixed sensor for detecting the passage of said movable element and outputting a detection signal in response thereto, and a latch circuit whose output is inverted when triggered by a detection signal from said fixed sensor,

said method comprising the steps of:

supplying a reversing pulse for rotating said pulse motor in the reverse direction to said pulse motor in case no detection signal is outputted from said fixed sensor when said pulse motor stops after a detection signal has been outputted from said fixed sensor;

determining to be the normal origin, when said fixed sensor outputs a detection signal again during the reverse revolution of said pulse motor on supplying the reversing pulse to said pulse motor, a pause position where said pulse motor stops after having rotated in the reverse direction; and

supplying again an advancing pulse for rotating said pulse motor in the normal direction, when said fixed sensor outputs no detection signal during the reverse revolution of said pulse motor on supplying the reversing pulse to said pulse motor, and determining to be the normal origin a pause



position where said pulse motor stops after having rotated in the normal direction by one step.

2. A pulse motor origin detecting apparatus comprising:
a movable element for use in detection of a position mounted to the rotatable output axis of a pulse motor;

a fixed sensor for detecting the passage of said movable element and outputting a detection signal in response thereto;

a latch circuit whose output is inverted when said latch circuit is triggered by a detection signal from said fixed sensor in the state that said pulse motor is rotating in the normal direction;

stop control means for stopping the normal revolution of said pulse motor when the output of said latch circuit is in the inverted state;

a reversing pulse generator for generating a reversing pulse for rotating said pulse motor in the reverse direction by a predetermined number of step when said pulse motor is stopped by said stop control means and a pause position of said movable element stopped with the stop of said pulse motor does not conform with the position of said fixed sensor;

an advancing pulse generator for supplying again an advancing pulse for rotating said pulse motor in the normal direction to said pulse motor when no detection signal is generated from said fixed sensor in the state that said pulse



motor has been rotated in the reverse direction by the reversing pulse from said reversing pulse generator; and

a controller for determining, in the state that the output of said latch circuit is inverted, to be the normal origin, in case a detection signal is outputted from said fixed sensor when said pulse motor is stopped by said stop control means, a pause position where said pulse motor is stopped, and in case no detection signal is outputted from said fixed sensor when said pulse motor is stopped, to be the normal origin, when a detection signal is outputted from said fixed sensor in the state that said pulse motor has been rotated in the reverse direction by the reversing pulse from said reversing pulse generator, a pause position where said pulse motor stops after its reverse revolution, and when no detection signal is outputted from said fixed sensor in the state that said pulse motor has been rotated in the reverse direction, a pause position where said pulse motor stops after having rotated in the normal direction by the advancing pulse from said advancing pulse generator from said pause position of said pulse motor having rotated in the reverse direction.

3. A method of detecting an origin to an angular position of rotation of the rotatable output axis of a pulse motor using a movable element for use in detection of a position mounted to the rotatable output axis of said pulse motor, a fixed sensor for detecting the passage of said



movable element and outputting a detection signal in response thereto, and a latch circuit whose output is inverted when triggered by a detection signal from said fixed sensor,

said method comprising the steps of:

supplying an advancing pulse for rotating said pulse motor in the normal direction to said pulse motor;

detecting the inversion of the output of said latch circuit caused by a detection signal outputted from said fixed sensor each time said movable element passes through the position of said fixed sensor during the normal revolution of said pulse motor; and

controlling to stop said pulse motor when the inversion of the output of said latch circuit is detected,

said step of controlling further comprising, in case a pause position of said movable element does not conform with the position of said fixed sensor, the steps of:

returning the angular position of rotation of said pulse motor back to a retreat position which is subjected to no effect of an overshoot by rotating said pulse motor in the reverse direction;

increasing the number of steps of revolution of said pulse motor in the normal direction by one step than that of said pulse motor in the reverse direction when rotating said pulse motor again in the normal direction from said retreat position; and

repeating said reverse revolution of said pulse motor to said retreat position followed by said normal revolution of



said pulse motor from said retreat position with the number of steps increased by one step than that of said reverse revolution until a detection signal is outputted from said fixed sensor when said pulse motor is returned back to said retreat position.

4. A pulse motor origin detecting apparatus comprising:
a movable element for use in detection of a position mounted to the rotatable output axis of a pulse motor;
a fixed sensor for detecting the passage of said movable element and outputting a detection signal in response thereto;

a latch circuit whose output is inverted when said latch circuit is triggered by a detection signal from said fixed sensor in the state that said pulse motor is rotating in the normal direction;

stop control means for stopping the normal revolution of said pulse motor when the output of said latch circuit is in the inverted state;

a reversing pulse generator for applying a reversing pulse for returning the angular position of rotation of said pulse motor back to a retreat position which is subjected to no effect of an overshoot by rotating said pulse motor in the reverse direction by N steps in case said pulse motor is stopped by said stop control means and a pause position of said movable element stopped with the stop of said pulse motor does not conform with the position of said fixed



sensor;

an advancing pulse generator for applying to said pulse motor an advancing pulse for rotating said pulse motor in the normal direction by said reverse revolution steps N plus one step, namely, $(N+1)$ steps in case no detection signal is generated from said fixed sensor when said angular position of rotation of said pulse motor is returned back to said retreat position by the reversing pulse from said reversing pulse generator; and

a controller for determining, in the state that the output of said latch circuit is inverted, to be the normal origin, in case a detection signal is outputted from said fixed sensor when said pulse motor is stopped by said stop control means, a pause position where said pulse motor is stopped, and for returning the angular position of rotation of said pulse motor back to said retreat position, in case said pulse motor is stopped and a pause position of said movable element does not conform with the position of said fixed sensor, by rotating said pulse motor in the reverse direction by N steps by the reversing pulse from said reversing pulse generator, said controller determining to be the normal origin, when a detection signal is outputted from said fixed sensor in the state that said pulse motor has been rotated in the reverse direction, a pause position where said pulse motor stops after having rotated in the normal direction by $(N-1)$ steps from said retreat position after its reverse revolution, and supplying to said reversing pulse



generator an instruction for causing said reversing pulse generator to generate the reversing pulse when no detection signal is outputted from said fixed sensor in the state that said pulse motor has been rotated in the reverse direction.

