The sensor comprises means for generating a reference pulse every predefined number of pulses of said signal.
"Actuating system with improved rotational sensor"

**DESCRIPTION**

The invention relates to an actuating system for roller shutters or sliding barriers or the like with an improved rotational sensor.

In order to check/control the angular position of mechanical parts in automated systems, sensors which may be classified as "absolute sensors" and "relative sensors" are used. The former give an angular position expressed as an absolute value (between zero and an end-of-scale value) and may be linear or digital (encoders). In the first case an analog value (for example the resistance value of a potentiometer) is measured, while in the second case costly absolute digital encoders of the optical type are used, these consisting of a disk which is perforated so as to encode directly as a multiple-bit binary value its angular position, intercepting or allowing through multiple light beams. These transducers are complex and costly because they use several light detectors. The system which is most used, because it is simple and reliable, is instead the "relative" digital sensor or incremental encoder, shown in Fig. 1. It consists of an opaque disk DK which is integral and coaxial with the axis of rotation of a shaft SH to be monitored. The disk DK has a certain number of transparent windows TK which are angularly equidistant from each other and through which a light ray R emitted by a source TX, usually an LED diode, and directed towards a detector RX, for example a phototransistor, is able to pass. The ray R is interrupted by the disk DK whenever a window TK is not aligned with it. In this way, by counting the number of pulses detected by the detector RX (the number of times the detector RX detects the ray R) it is possible to determine the variation in the angle of rotation. From the point of view of the calculation to be performed, it consists of a simple count which whenever the ray R is received increments or decrements (depending on the direction of rotation of the shaft SH) the value which represents the current position. The resolution of the sensor depends on the number of slits in the disk. The advantage over the absolute measurement version is the use of a single detector RX, resulting in much lower costs and smaller dimensions.

In some systems the direction of rotation of the shaft SH is not known beforehand, so that a second detector (not shown) is provided, said detector being identical to the first one RX, but angularly phase-displaced with respect to it. In this way, by detecting a second ray R, a digital signal phase-displaced by 90° is generated (see digital signals OUT A, OUT B with the respective analog signals CH A, CH B in Fig. 2). In this way, an encoder may easily detect the direction of rotation, for example by verifying the logic level of the output OUT B at each switching front of the output OUT A.

The major disadvantage of relative (incremental) encoders is that the count value (i.e.
the position according to the encoder) is not directly related in any way to the real position. In some applications, however, an absolute position value is required. For example, in the case of the movement of a curtain or a blind, the real (physical) position is of fundamental importance. During the initial stage of installation of diii type of automated system, since each system could have its own travel movement with a different length, the end-of-travel positions are programmed, generally by means of “self-learning”, i.e. by physically positioning the roller shutter in the end-of-travel positions and storing the latter.

As soon as the first end-of-travel position has been fixed, that position may be regarded as the zero reference position. Then, the count system starts from the zero position and is subsequently able to establish the relative position with respect to the zero position.

There may be different variants. "Optical" systems (LED + phototransistor), which are particularly sensitive to dust and dirt, are often replaced by magnetic systems, for example a disk magnetized in different N-S segments and Hall effect sensors or other field sensors. The principle, however, remains the same.

In incremental encoders it is of fundamental importance to keep die position count perfectly related to die real position. If, for any reason, there should be an error (for example, a pulse should not be counted), diii would represent a position error equivalent to one unit of angular resolution. If this error should be repeated, it would be added to die previous error and very soon the position of the roller shutter would be out of control.

For this reason, relative encoders must in all cases be associated with a non-volatile memory which permanently stores the position detected before (deliberate or unintentional) interruption of die power supply.

The reasons why a pulse may not be counted are many, for example:

- in the event of interruption of the power supply, die structure on which the roller shutter is mounted may continue to oscillate as a result of the varying play present in the components of die motor/ roller shutter kinematic chain despite blocking of die motor. If die oscillation should continue for a long time, an incorrect value could be stored;

- external phenomena (gusts of wind), heat expansion due to variations in temperature or impacts on the blind may move die roller shutter again even after it has stopped, causing it to assume a position different from that stored.

All this has particularly serious repercussions in systems which are often subject to power failures or which are controlled with the person present, namely which are powered only for die period during which the operation is performed. If during the period when no power supply is present (and therefore the encoder is unable to operate) the disk DK should move, upon reactivation of the system (with the next operation) the "difference" in position would not be perceived by the system and therefore the position of die blind would be
different from that resulting from the sensor.

In transducers with two digital outputs OUT A, OUT B, the displacement by a position (one only) could be detected and corrected even if it occurred when there was no power (see Fig. 3). Before interruption of the power, the logic status of the two outputs OUT A, OUT B (of the detectors) is stored. Upon reactivation, it is checked whether the logic status is still the same (and hence it is assumed that there has been no movement) or if the logic status has varied following a movement. The table in Fig. 3 shows the sequence of logic statuses for the outputs OUT A, OUT B before and after a hypothetical position X. If, for example, the stored logic status for the position X was "A=O and B=O" and upon reactivation was "A=I and B=O" it may be assumed that there has been a movement into the position X+1; on the other hand, if the level were "A=O and B=I" the position would be X-1.

This method, however, manages to retrieve only the movement by one position, because if the logic status were "A=I and B=I" there would be no way to establish whether the new position is X-2 or X+2.

In an attempt to solve the problem of the position error, known systems use two methods:

- Reducing the resolution of the sensor to a value which is certainly less than the mechanical play present in the system. This solves the root of the problem (there cannot be any error) but reduces the performance of the gear motor. If, for example, the sum of the play should be equal to ±10° the encoder system must have a resolution less than 36 pulses/revolution; the precision of the system will therefore also be less than 36 pulses/revolution. In the case of a blind wound onto a roller with a diameter for example of (only) 20 cm this would correspond to a precision in the travel movement of 17 mm, a generally unacceptable value. When applying this method it will therefore be necessary to find a compromise between the precision obtained and the risk of an error affecting the encoder.

(ii) Ignoring the problem completely and making use of the fact that most blinds have a mechanical end-of-travel stop which locks it in the completely open position, often very close to the stored position of the corresponding end-of-travel stop. Reasonably every 10 to 20 operations completed the motor is stopped precisely in the mechanical end-of-travel position instead of the stored position, by moving the blind so that it makes banging contact. The impact is detected by means of the same encoder on the basis of the reduction in the speed of rotation of the disk. Basically the zero position of the encoder is recalibrated from time to time. It is evident that this method is applicable only in the case of blinds with suitable and strong end-of-travel systems and in any case the structure is subject to a stress which could in the long term cause damage.
The main object of the invention is to provide an actuating system with a rotational sensor which allows correction of the angular position error.

These objects are achieved according to the invention with an actuating system for roller shutters, sliding barriers or the like, comprising a rotational sensor for controlling and/or measuring the relative angular position of a shaft or a rotating spindle able to generate a signal with a number of pulses proportional to the angle moved through, characterized in that die sensor comprises means for generating a reference pulse every predefined number $N$ of pulses of said signal.

The reference pulse is used as an indicator for checking the number $N$ of pulses generated (to which a certain angular variation corresponds). If the pulse count is not equal to $N$ or a multiple thereof, then there has been an error which may be corrected.

The invention proposes a method for correcting the error in the angular position of a shaft or a rotating spindle, in which at least one signal with a number of pulses proportional to the angle moved through is generated and said number is counted in order to calculate die angular variation, characterized by:

- generating a reference pulse every predefined number of successive pulses of said signal;
- calculating the difference between the number of pulses in said signal, counted between a reference pulse and the next one, and the predefined number;
- in the event of a difference which is not equal to zero, correcting die pulse count by adding and subtracting said difference. Advantageously it is possible to calculate said difference with a modulus operation carried out on the counted value, where the base of the modulus is the said predefined number of pulses.

In order to simplify the calculations, die means for generating die reference pulse may be preset to generate a pulse with a substantially multiple time period compared to die pulses of said signal, for example every round angle moved through by the shaft or the spindle.

The means for generating the reference pulse may comprise a disk with transparent windows which are angularly equidistant and at least one of which is opaque (or in any case different from die other windows) so as to generate a reference pulse with a period greater than die other pulses. Accordingly the processing means are designed to detect the period of each pulse obtained via said disk and interpret die pulse which has a period greater than die other ones as die reference pulse.

In order to implement die method, die actuating system (or the sensor in an integrated manner) may comprise processing means for correcting an angular position error of the shaft or die rotating spindle which are designed to:

- calculate the difference between die number of pulses in said signal, counted
between one reference pulse and the next one, and said predefined number;
   - in the case of a difference not equal to zero correcting the pulse count by adding or
   subtracting said difference.

The advantages according to the invention will be explained more fully by the
following description of a preferred embodiment, illustrated in the accompanying drawing in
which:

Fig. 1 shows a known sensor;
Fig. 2 shows a set of signals generated by a known sensor;
Fig. 3 shows a table with logic statuses generated by a known sensor;
Fig. 4 shows a sensor according to the invention;
Fig. 5 shows a set of signals generated by the sensor according to Fig. 4.

Fig. 4 shows a sensor device 10 according to the invention. The parts with reference
numbers the same as those already mentioned are to be regarded as identical and will not be
described for the sake of brevity.

As can be seen, the sensor 10 also comprises a disk DK2, which is coaxial and integral
with the disk DK, with a single through-window TK2 which may intercept or allow through a
light beam R2 emitted by an emitter TX2 and directed towards a detector RX2. Detection of
the beam R2 in the detector RX2 is performed in a known manner, as already seen, with a
beam R2 every complete rotation of the disk DK2. The window TK2 is angularly phase-
displaced with respect to the closest one on the disk DK.

Even though it is preferable that the disk DK of the sensor should have a large
number of "windows" TK, in order to obtain the maximum resolution and therefore
precision in the position, as a simplified example we shall consider a disk DK with only 12
windows. By combining the sensor 10 with a 1:10 revolution multiplier an angular resolution
of 3° is achieved. In the case of a blind with a roller having a diameter of 20 cm a precision in
its travel movement of 5.2 mm is obtained. It is clear, however, that an (unintentional)
displacement of the blind greater than 5.2 mm would cause a reading error of the sensor 10.
To avoid this problem, the second disk DK2 is used.

If the signals generated by the detectors RX and RX2 for a round angle performed by
the disks DK and DK2 are plotted along the axis for die angles φ die results shown in Fig. 5
are obtained. We shall represent with OUT A the signal generated with the disk DK and with
OUT C the signal generated with the disk DK2. For every 12 pulses in OUT A a pulse in
OUT C is generated and therefore die signal OUT C may be regarded as a synchronization
and reference pulses which returns with each round angle. The reference pulse in OUT C is
used to correct any errors present in the position count which is performed by the disk DK
and the detector RX (or by a multiplicity of other detectors in the case where various main
disks are used).

Whenever the synchronization signal OUT C is detected, the count value must always be a multiple of 12. If it has a different value this means that an error has occurred. The error could be positive or negative (the count was higher or lower) with respect to the real value and at the most (in this example) it is possible to correct an error of 6 pulses. In order to determine whether the error is positive or negative it is sufficient, at the falling edge of the pulse OUT C (in the case of a forwards count) or at the rising edge (in the case of a backwards count), to calculate the modulus 12 of the counter value. If the result of the modulus is 0, then there has been no error; if the result of the modulus is between 7 and 12 this means that the error is negative (value less than what it should be); if the result of the modulus is between 1 and 6 this means that the error is positive (value greater than what it should be).

Compensation of the error is performed by simply adding (in the first case) or subtracting (in the second case) the value of the error detected to/from the value of the counter.

The great advantage of use of the auxiliary disk DK2 is the possibility of combining with the optimum precision of the main disk(s) DK (using a signal OUT A with a large number of pulses, i.e. a high resolution) the characteristic feature of error compensation equivalent to up to half the round angle of the disk (or disks) DK via the signal OUT C. The method can be easily adapted to disks DK with a different number of notches N, whereby the compensation may again be N/2 pulses (negative or positive difference).

Clearly, in addition to the optical systems with disks which have transparent/through windows, it is possible to use known systems with Hall effect sensors which may or may not be acted on by magnetic field depending on the position of one or more rotating disks. It is possible to generate a reference (synchronization) pulse eliminating one of the notches already present on one of the main disks DK. In this case, since the motor (and therefore the disk DK) rotates at a practically constant speed, the missing pulse may be detected by measuring the time (period) of each pulse: the pulse which has a period twice that of the other pulses is the synchronization pulse. This therefore has the advantage of eliminating the disk DK2 and the associated components TX2, RX2. The same result would be obtained with the solution which uses, as means for generating a reference pulse for an angular variation of one round angle of the shaft being verified, co-operation between a conductive track integral with the shaft and a fixed frictional contact which, upon making contact therewith, closes a circuit and generates an electric pulse. Other variants may nevertheless be implemented, ensuring a limited complexity of the system.

In all cases the calculation of the period or the number of pulses in the signals OUT
A, OUT C may be performed by a processing unit CC which detects the signals OUT A, OUT C by the detectors RX2 and RX2 and processes them. The unit CC may control directly the motor M of the actuating system or exchange data with a central unit ALU.
CLAIMS

1. Actuating system for roller shutters, sliding barriers or the like, comprising a rotational sensor for controlling and/or measuring the relative angular position of a shaft or a rotating spindle able to generate a signal with a number of pulses proportional to the angle moved through, characterized in that the sensor comprises means for generating a reference pulse every predefined number of pulses of said signal.

2. Actuating system according to Claim 1, in which said generating means are designed to generate a reference pulse with a time period which is substantially a multiple of the pulses of said signal.

3. Actuating system according to Claims 1 or 2, in which said generating means are designed to generate a reference signal every round angle moved through by the shaft or the spindle.

4. Actuating system according to Claims 2 or 3, in which said generating means comprise a disk integral with the shaft or with the rotating spindle able to interact with a field sensor in a predetermined angular position.

5. Actuating system according to Claim 4, in which in said predetermined angular position the disk has a transparent window which can be passed through by a light beam directed towards a photosensor.

6. Actuating system according to Claim 4, in which said predetermined angular position the disk has a zone suitable for interacting with a magnetic field sensor.

7. Actuating system according to any one of the preceding claims, comprising processing means for correcting an angular position error of the shaft or the rotating spindle, which are designed to:

- calculate the difference between the number of pulses in said signal, counted between a reference pulse and the next pulse, and said predefined number;

- in the event of a difference not equal to zero correct the pulse count by adding or subtracting said difference.

8. Actuating system according to any one of the preceding claims, in which the processing means are designed to calculate said difference by means of a modulus operation on the counted value, where the base of the modulus is the said predefined number of pulses.

9. Actuating system according to any one of Claims 5 to 7, in which said generating means comprise a disk with transparent windows which are angularly equidistant and at least one of which is different, for example opaque, for generating a reference pulse with a period greater than the other pulses.

10. Actuating system according to Claim 9, in which the processing means are
designed to detect the period of each pulse obtained by means of said disk and to interpret
the pulse which has a greater period than the other pulses as the synchronization pulse.

11. Method for correcting the error in the angular position of a shaft or a rotating
spindle, in which at least one signal with a number of pulses proportional to the angle moved
through is generated and said number is counted in order to calculate the angular variation,
characterized by:

- generating a reference pulse every predefined number of successive pulses of said
  signal;
- calculating the difference between the number of pulses in said signal, counted
  between a reference pulse and the next pulse, and the predefined number;
- in the event of a difference not equal to zero correcting the pulse count adding or
  subtracting said difference.

12. Method according to Claim 11, in which said difference is calculated with a
modulus operation on the counted value, where the base of the modulus is the said
predefined number of pulses.
FIG. 4

FIG. 5