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(54) Title: FORCE REGULATED ANTI-PINCH WINDOW REGULATOR SYSTEM

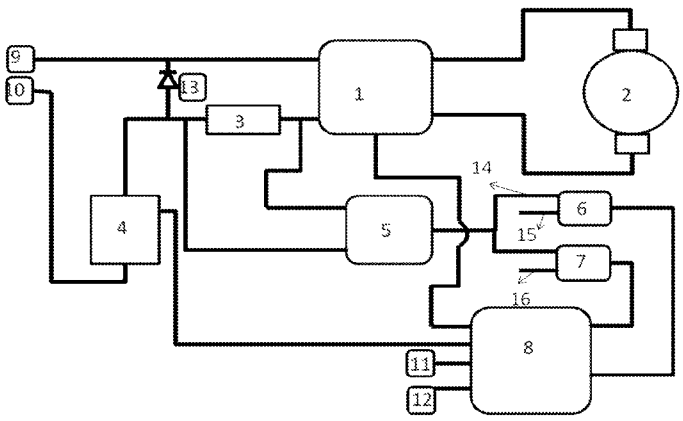

FIGURE 1

(57) Abstract: The present invention discloses a force regulated anti-pinch window regulator system. The system includes a motor (2) with a means to control the direction of rotation (1) of the motor (2) and hence the movement of a window glass. The system also has two comparators, wherein each comparator receives two inputs. The system has a controller unit (8) which governs the current regulation within the upper threshold value of the first comparator (6). The current regulation is achieved by hysteresis current control method. If the value of current is between the upper threshold and the lower threshold for a certain period of time Thigh, an intrusion is detected. Correspondingly, the motor is stopped in the case of a hard intrusion, and the direction of movement of the window is reversed completely or for a timed duration in the case of a soft intrusion.

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TITLE OF THE INVENTION

FORCE REGULATED ANTI-PINCH WINDOW REGULATOR SYSTEM

[0001] Technical field of the invention

[0002] The present invention discloses a force regulated anti-pinch window regulator system. The system particularly discloses a means for implementing a desired motion of a glass in an upward direction or downward direction as desired by a user, simultaneously ensure safety of the occupants during movement of the glass.

[0003] Background of the invention

[0004] The functional requirement of a window regulator system is to move the window glass up or down as per user requirements. A typical window regulator system is one in which the user directly controls the direction of the current and hence the direction of movement of the window glass. However in these types of systems the movement is supported as long as the direction control button is pressed. The user detects that the end of stroke has been reached and would then release the switch, thus turning off the current. As a functional improvement, it is the present trend to provide an express down function. The express down function allows the window to be fully lowered with one tap on the switch, as opposed to holding the switch down until the window retracts. While express down is activated, the control will remain latched till such a time as the bottom limit is encountered and then turn off the current. The same facility when provided for an upward motion has a safety requirement that the glass movement should be carried out in a controlled manner wherein if there is an intrusion/obstruction to the glass movement, the same has to be detected to prevent injury to any body parts of the occupants. This facility is called the anti-pinch system.

[0005] Hence what is needed is an easy to implement, simple, inexpensive system to control the anti-pinch window regulator without using memory elements and numerous sensors.

[0006] Summary of the invention

[0007] According to an embodiment, the invention discloses a force regulated anti-pinch window regulator system. The system includes a motor with a means to control the direction of rotation of the motor and hence the movement of a window glass. The system also has two comparators, a first comparator configured to receive a first input and a second input, wherein the first input is the voltage which is proportional to current flowing through the motor and the second input is a reference voltage corresponding to the upper threshold value (I_{ref1}) of current. System includes a second comparator configured to receive a first input and a third input, wherein the first input is the voltage which is proportional to current flowing through the motor and third input is a reference voltage corresponding to the lower threshold value (I_{ref2}) of current. The system also has a controller unit to control the direction of rotation of the motor based on an input from the user. The controller unit governs the current regulation within the upper threshold value of the first comparator. The current regulation by the controller unit is being enforced by the hysteresis current control method by using the first comparator and the second comparator. When the value of drawn current (I) is between the upper threshold value (I_{ref1}) and the lower threshold value (I_{ref2}) for a certain period of time $T_{high,}$ then an intrusion is detected. Based on the rate of change of drawn current, a distinction between a hard stop and a soft stop is achieved. A high rate of change of drawn current (I_{slope}) is considered as a hard stop and hence the limit of movement and the means of directional control to the motor must be switched off so that the motor stops working. A low rate of change of drawn current (I_{slope}) is considered as a soft stop and in this case, the direction of window needs to be reversed i.e. the window should be made to go downwards. This is accomplished by reversing the direction of current in the motor, with the help of the means of directional control block. This reversal can happen until the window reaches the bottom. In another embodiment, this can be done by reversing the window direction for a timed duration, hence protecting the obstruction.

[0008] According to another embodiment, the system includes a first limit sensor to detect the top limit of movement of the window glass which senses when the window glass has reached the top of the window frame. The system also has a

second limit sensor to detect the bottom limit of movement of the window glass which senses when the window glass has reached the bottom of the window frame.

[0009] In another embodiment, the window glass is also opened and closed in the horizontal direction, which means the same as upward direction and downward direction respectively.

[0010] The system disclosed eliminates the need of component on the rotor shaft to trigger the sensor, and memory elements; thereby the overall cost of the design is reduced making the system more suitable for applications in auto-motive industry. The reliability of the system increases significantly as the overall number of components is reduced. The current drawn by the motor never reaches the stall current value. As the current remains lower than upper threshold value, the life of components involved is increased, and this also reduces cost. The current level being maintained at a lower level permits the downsizing of the capabilities of the components thus further reducing the cost, or in case the same components are retained then the life would be enhanced. The heat build-up in the circuit is reduced significantly, thereby increasing the life time of the motor and the components.

[0011] It is to be understood that both the foregoing general description and the following details description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

[0012] Brief description of the drawings:

[0013] The foregoing and other features of embodiments will become more apparent from the following detailed description of embodiments when read in conjunction with the accompanying drawings. In the drawings, like reference numerals refer to like elements.

[0014] Figure 1 illustrates the block diagram of a force regulated anti-pinch window regulator system in accordance with an embodiment of the invention.

[0015] Figure 2 illustrates the process flow for a force regulated anti-pinch window regulator systemin accordance with an embodiment of the invention.

[0016] Detailed description of the invention:

[0017] Reference will now be made in detail to the description of the present subject matter, one or more examples of which are shown in figures. Each embodiment is provided to explain the subject matter and not a limitation. These embodiments are described in sufficient detail to enable a person skilled in the art to practice the invention, and it is to be understood that other embodiments may be utilized and that logical, physical, and other changes may be made within the scope of the embodiments. The following detailed description is, therefore, not be taken as limiting the scope of the invention, but instead the invention is to be defined by the appended claims.

[0018] The invention discloses an anti-pinch window regulator system which includes a motor coupled to a window regulator mechanism. The motor is suitably coupled to the window glass in order to implement the window glass movement in upward or downward direction. The motor used herein is a DC motor. The invention makes use of current regulation for implementing anti-pinch window regulator system. The current regulation is achieved by means of hysteresis current control method.

[0019] Figure 1 illustrates the block diagram of a force regulated anti-pinch window regulator system in accordance with an embodiment of the invention. The system includes a motor **(2)** with a means to control the direction of rotation **(1)** of the motor and hence the direction of movement of the window glass. The system also has two comparators, a first comparator **(6)** configured to receive a first input (**14**) and a second input (**15**), wherein the first input (**14**) is the voltage which is proportional to current flowing through the motor and the second input (**15**) is a reference voltage corresponding to the upper threshold value (I_{ref1}) of current. The system includes a second comparator **(7)** configured to receive a first input (**14**) and a third input (**16**), wherein the first input (**14**) is the voltage which is proportional to current flowing through the motor **(2)** and third input (**16**) is a reference voltage corresponding to the lower threshold value (I_{ref2}) of current. The

system also has a controller unit **(8)** to control the direction of rotation of the motor **(2)** based on an input from the user. The controller unit has the direction input up latch (**11**) and direction input down latch (**12**), wherein it operates based on an input from the user. The blocks (**9**) and (**10**) represent positive terminal and negative terminal respectively. The system also has the freewheeling diode (**13**) into a circuit to protect the switching device from being damaged. The controller unit **(8)** governs the current regulation within the upper threshold value of the first comparator **(6)**.The current regulation by the controller unit **(8)** is being enforced by a current regulation means **(4)** by using the hysteresis current control method by using the first comparator **(6)** and the second comparator **(7).** The block (**3**) represents a means of sensing the current. The block (**5**) represents a means for measuring the difference of voltage which is fed to the first and the second comparators. When the value of current is between the upper threshold and the lower threshold for a certain period of time T_{high} then an intrusion is detected. Based on the rate of change of drawn current (I_{slope}), a distinction between the two types of intrusions is made. A high rate of change of drawn current (I_{slope}) is considered as a hard stop and the limit of movement of the window glass. Hence in this case, the supply to the motor should be removed. This is done with the means of direction control. A low rate of change of drawn current (I_{slope}) is considered as a soft stop, and in this case, the window must be made be made to go downwards. This is done by reversing the direction of current through the motor, again through the means for directional control. This reversal can be done till the window reaches the bottom completely, or for a timed duration.

[0020] The controller unit **(8)** generates the command in response to a drawn current of the motor. The controller unit **(8)** governs the current regulation below the upper threshold value (I_{ref1}) of the first comparator **(6)**. If the drawn current (I) is between the upper threshold value (I_{ref1}) and the lower threshold value (I_{ref2}) for a certain of time T_{high} an intrusion is detected. The rate of change of drawn current (I_{slope}) is considered as a measure to distinguish between a hard intrusion and a soft intrusion. A higher rate of change of drawn current (I_{slope}) with respect to time is considered as a hard intrusion. The occurrence of hard intrusion indicates that the window glass has reached the top of the window frame and the motor is switched off immediately. A lower rate of change of drawn current (I_{slope}) with

respect to time is considered as a soft intrusion. When the system identifies a soft intrusion, the direction of rotation of the motor **(2)** is reversed for certain duration of time and later the motor **(2)**is switched off in one implementation. In another implementation the window is lowered all the way to the bottom stop.

[0021] Figure 2 illustrates the process flow (**100**) for a force regulated anti-pinch window regulator system in accordance with an embodiment of the invention. At step (**101**), the system checks whether the controller unit receives the input from the user to move the window upward or downward. If the window is driven upward, then a check is made at step (**102**) as towhether the drawn current (I) is at the upper threshold value (I_{ref1}) or not**.** If the drawn current(I) is lower than the upper threshold value (I_{ref1}), the motor continues to run and the upward motion of the window glass would be continued at step (**103**).If the result of the check made at step **(102)** is affirmative which means that the drawn current (I) is at the upper threshold value (I_{ref1}), a check is made at step (**104**), to check whether drawn current (I) is higher than the lower threshold value (I_{ref2}) for a predetermined period of time T_{high}. If the result is affirmative, the rate of change of drawn current (I_{slope}) is checked at step (**105**) to distinguish between the two kinds of intrusions, i.e. if the rate of change of current (I_{slope}) with respect to time is lower it is termed that, the window has encountered a soft intrusion and if higher is the rate of change of current (I_{slope}) with respect to time, it is termed as a hard intrusion. The hard intrusion indicates that the window glass has reached the top of the window frame at step (**106**) and the motor is switched off immediately at step (**107**).

[0022] If the result of the check made at step **(105)** is affirmative which means that the rate of change of drawn current with respect to time is lower, then a check is made at step (**108**). At step (**108**) system checks whether the motor reversal is to be continued till it reaches the bottom. If the step (**108**) is affirmative the motor direction is reversed (**109**) until it reaches the bottom, otherwise as per step (**114**) system reverses the motor direction for a particular duration of time and then switches off the motor. At step (**110**) the system again checks whether the drawn current (I) is at the higher threshold value (I_{ref1}). If the step (**110**) is affirmative, a system at step (**112**) checks whether drawn current (I) is greater than the lower threshold value (I_{ref2}) for a predetermined time (T_{high}) or not. If the drawn current

(I) is lower than the lower threshold value (I_{ref2})for predetermined time (T_{high}) at step (**112**), the downward motion of the window glass is continued as per step (**111**). If step (**112**)is affirmative the system identifies that window has reached the bottom and the motor gets switched off at step (**113**).

[0023] The invented system eliminates the need of hall-effect sensors, speed sensors and the memory elements in automatic windows, thereby reducing the overall cost of the design and makes the system more suitable for applications in auto-motive industry. The reliability of the system increases significantly as the overall number of components is reduced. The current drawn by the motor never reaches the stall current value. The current being regulated at a value lower than the upper threshold increases the life of the components involved and/or also downsizing the capabilities of the components hence reducing costs. The heat build-up in the circuit is reduced significantly, thereby increasing the life time of the motor.

[0024] The cost of most of the existing anti-pinch safety devices is very high. Thus the anti-pinch feature is only available with selective models or is provided as an optional feature at a significantly higher cost at present. It is the intent and strong desire of the present invention to make the implementation affordable on all base models of automotives.

[0025] It is to be understood, however, that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only. Changes may be made in the details, especially in matters of shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

[0026] Claims:

[0027] We claim:

1. A force regulated anti-pinch window regulator system, comprising:

    a. a motor (**2**) with a means to control the direction of rotation (**1**)of the motor (**2**) and hence the movement of a window glass;

    b. a first comparator (**6**)configured to receive a first input (**14**) and a second input (**15**),wherein the first input (**14**) is a voltage which is proportional to current flowing through the motor (**2**) and second input (**15**) is a reference voltage which corresponds to the upper threshold value of current;

    c. a second comparator (**7**)configured to receive a first input (**14**) and a third input (**16**), wherein the first input (**14**) is the voltage which is proportional to current flowing through the motor (**2**) and third input (**16**) is a reference voltage which corresponds to the lower threshold value of current; and

    d. a controller unit (**8**) to control the direction of rotation of the motor (**2**) based on an input from the user, wherein the controller unit (**8**) governs the current regulation within the upper threshold value of the first comparator (**6**),wherein current regulation by the controller is being enforced by the hysteresis current control method, by using the first comparator (**6**)and the second comparator (**7**), when the value of current is between the upper threshold and the lower threshold for a certain period of time T_{high}, an intrusion is detected based on rate of change of current, wherein a high rate of change of current is considered as a hard stop and limit of movement. A lower rate of change of current is considered to be a soft stop. In case of a soft stop, the window glass is completely brought down, or the upward motion of the window glass is reversed by reversing the direction of current through the motor, for a timed duration.

2. The system as claimed in claim 1, wherein the system further comprises:

    a. a first limit sensor to detect the top limit of movement of the window glass which senses when the window glass has reached the top of the window frame;
    b. a second limit sensor to detect the bottom limit of movement of the window glass which senses when the window glass has reached the bottom of the window frame.
    c. a combination of a sensor and the limit sensor at bottom position are used to evaluate the position and speed of the window glass of the window regulator.

3. The system as claimed in claim 1, wherein the window glass has closing and opening in the horizontal direction.

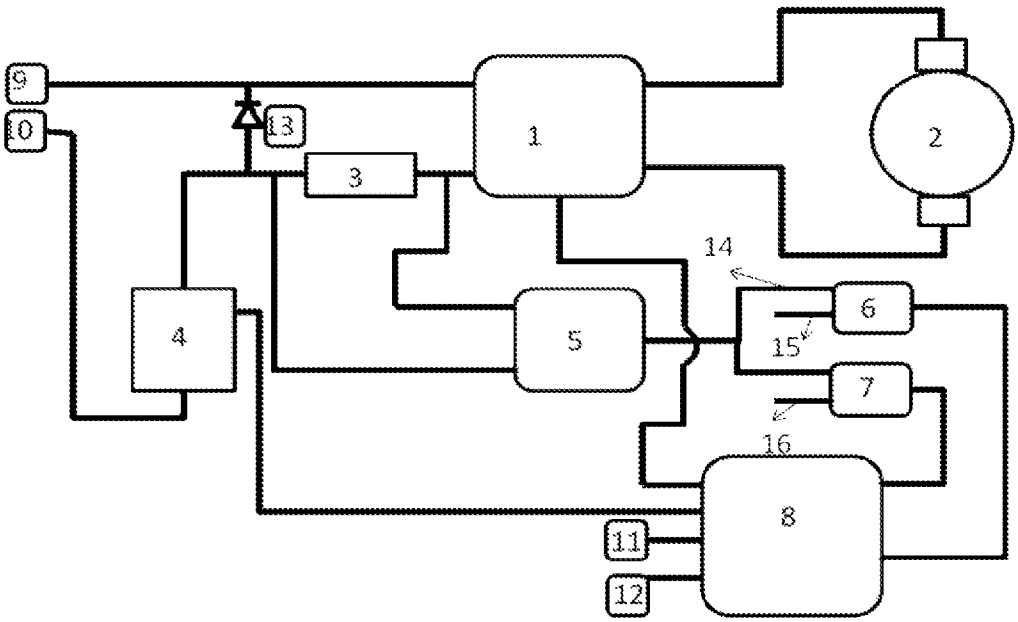

FIGURE 1

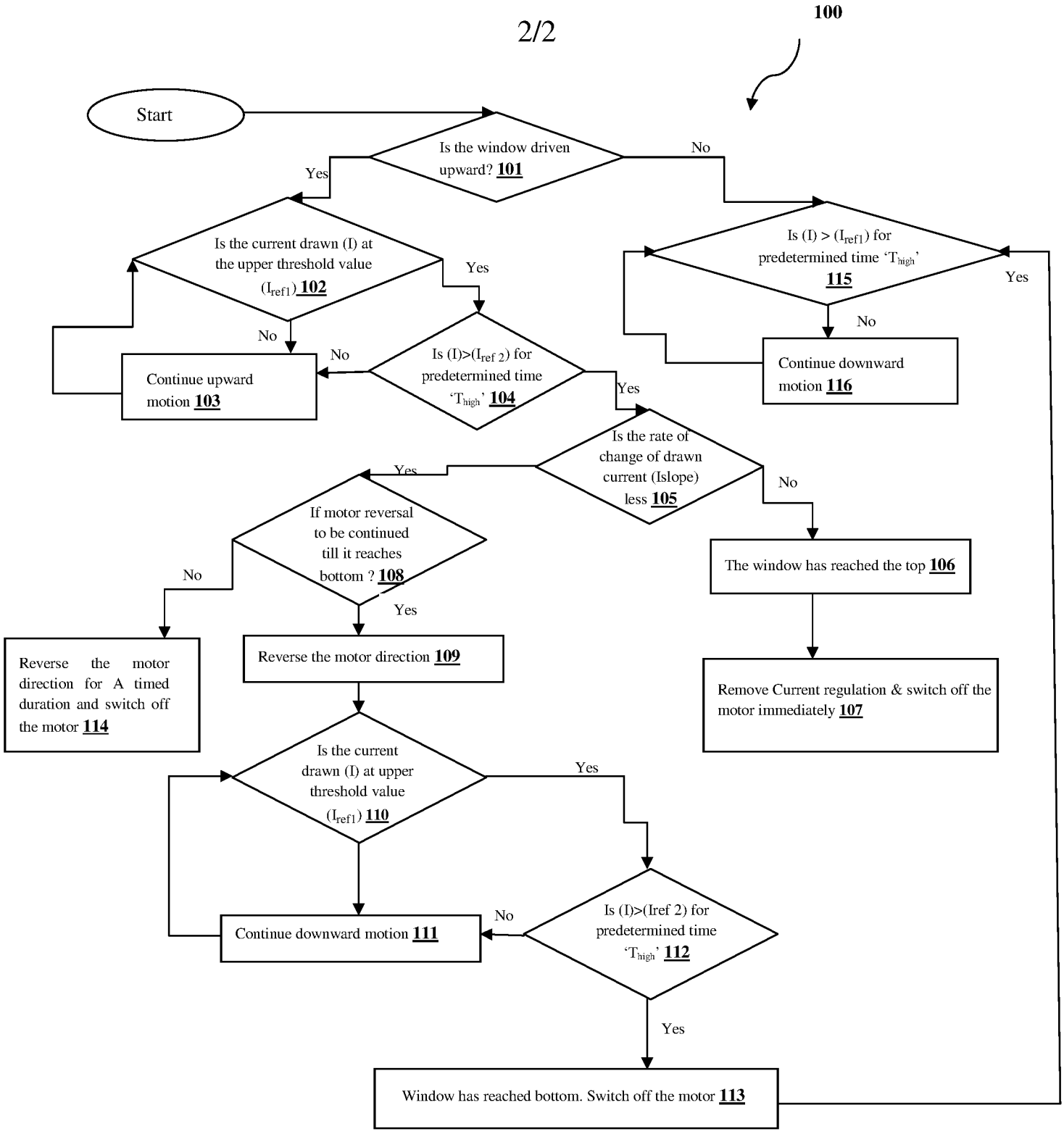
100
Start
Is the window driven upward? 101
Yes
No
Is the current drawn (I) at the upper threshold value (I_{ref1}) 102
Yes
No
Continue upward motion 103
No
Is (I)>($I_{ref\ 2}$) for predetermined time 'T_{high}' 104
Yes
Is (I) > (I_{ref1}) for predetermined time 'T_{high}' 115
Yes
No
Continue downward motion 116
Is the rate of change of drawn current (Islope) less 105
Yes
No
If motor reversal to be continued till it reaches bottom ? 108
No
Yes
Reverse the motor direction for A timed duration and switch off the motor 114
Reverse the motor direction 109
The window has reached the top 106
Remove Current regulation & switch off the motor immediately 107
Is the current drawn (I) at upper threshold value (I_{ref1}) 110
Yes
No
Continue downward motion 111
Is (I)>(Iref 2) for predetermined time 'T_{high}' 112
Yes
Window has reached bottom. Switch off the motor 113

FIGURE 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2014/065818

A. CLASSIFICATION OF SUBJECT MATTER
H03K17/00,E05F11/53,E05F15/00,G05F1/00,B60J1/00 Version=2014.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H03K,E05F,G05F,B60J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

DATABASES: PATSEER, IPO INTERNAL
SEARCH TERMS: ANTI PINCH,WINDOW REGULATOR,SENSOR

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7305290(RUSS DETLEF et al),15 SEPTEMBER 2005(15-09-2005) PARAGRAPHS-(0022-0024),(0030-0031),(0035-0038),(0045-0049), ABSTRACT,CLAIMS-(1-8,17)	1
X	US 20020047678(WILSON ROBERT H et al), 25 APRIL 2002(25-04-2002) PARAGRAPHS-(0007),(0012-0013), (0028,(0031-0032),(0048), ABSTRACT,CLAIM 1	2-3
E,Y	IN 1356/DEL/2013(PADMINI VNA MECHATRONICS PVT. LTD.), 12 DECEMBER 2014(12-12-2014) PAGE 5-LINES(10-20),PAGE -6 LINES(1-20),PAGE 9-LINES(1-15), PAGE 11-LINES(10-25), PAGE 12-LINES(1-15),ABSTRACT, CLAIMS -(1-8)	1-3

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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INTERNATIONAL SEARCH REPORT
Information on patent family members

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Citation	Pub.Date	Family	Pub.Date
US 7305290 A1	15-09-2005	EP 1552973 A2	13-07-2005
		DE 202004000266 U1	24-02-2005
		JP 2005194872 A	21-07-2005
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