CONTROL DEVICE FOR A SWING

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a conversion to a nonprovisional application under 35 U.S.C. § 111(b)(5) and 37 C.F.R. § 1.53(c)(3) of U.S. provisional application number 61/123,990, entitled "Speed and Oscillation Control Device for an Infant Swing", filed on April 11, 2008. This application also claims priority to U.S. provisional application number 61/123,898 entitled "Amplitude Control Device for an Infant Swing" filed April 11, 2008. Furthermore, this application claims priority to Chinese patent application number 200720053709.3 entitled "Dynamoelectric Swing Controls System" filed June 29, 2007.

BACKGROUND OF THE INVENTION

Infant swings, as well as the motor systems that control them, are well documented in the art. Traditionally, a swing consists of a seat which is supported at the distal end of one or more swing arms. A direct current (DC) motor is affixed between the support frame and swing arm such that the motor provides torque on one of the swing arms (the other being passively driven) to create the swinging motion of the seat. Existing art describes motor controllers that allow for a plurality of motion profiles which could be adjusted by means of a user interface. Previously, this was done by providing the motor with multiple, predetermined amounts of voltage, each producing a different torque from the motor and each corresponding to a motion profile. However, a swing operates on the principles of simple pendulum, and as such, the torque required from the motor to maintain a selected speed depends directly on the weight and location of the child in the seat. As a result, constant torque swings, although producing different motion profiles at each setting, also produce varying motion profiles for the same speed under different loading conditions, e.g., different sized children.

In an attempt to produce a consistent motion profile for each setting, under any loading condition, more recent art describes a feedback system which monitors the swing height at the end of each cycle and compares it to the desired swing height for the motion profile selected by the user. By comparing the desired swing arc with the actual swing arc, the motor controller can adjust the voltage to the motor and thus the torque it provides on the successive swings. This system, while providing a more consistent motion profile under various loading conditions for
the same swing, still operates under the principles of pendulum, and as such, the speed of the seat increases as it moves away from the endpoints of the motion path. Because this system is limited to varying the motor torque once per cycle, the motor provides an inconsistent velocity profile over the motion path, resulting in peak and valley type velocity changes.

BRIEF SUMMARY OF VARIOUS EMBODIMENTS OF THE INVENTION

Various embodiments of the invention include a motor driven infant or child swing and means for regulating the swinging motion of the swing. In particular, according to various embodiments, the swing includes a feedback system that provides a more consistent motion profile under any loading condition as well as a smoother velocity profile over the motion path. In particular embodiments, the swing produces a steady velocity over the entire motion path, which produces a smoother and gentler motion that results in a more calming effect than the swinging motions presented in existing art. Various embodiments also allow a user to select from a plurality of motion profiles, and the swing achieves the selected motion profile by comparing the measured velocity of the swing to a unique goal velocity associated with the selected motion profile. The selected motion profile is achieved, according to various embodiments, for any preprogrammed motion profile independent of the angle of travel by the pendulum or its direction.

Various embodiments of the present invention concern the motor system that produces the rocking motion in an infant or child swing, and more specifically, the motor control system which regulates the motion path of the swing. In various embodiments, the swing includes a base frame that is supported on the ground. The base frame includes a plurality of uprights extending from the base, and a plurality of swing arms are pivotably mounted to the uprights of the base frame at a connection point. A seat is mounted to the swing arms below the connection point. In a particular embodiment, each swing arm supports each side of the seat. A DC motor is affixed to the base frame, and a motor shaft of the motor provides a torque to one or more swing arms about the connection point.

According to various embodiments, the motor system includes the DC motor, a voltage supply, and a motor controller. The motor controller is used to regulate the voltage supplied to the motor. In one embodiment, motor feedback is provided by a light interrupter detector consisting of a slotted disk and an optical source/sensor. The slotted disk is mounted either
directly to the motor shaft or indirectly as by a gear box or the like. The optical source and sensor are positioned such that the slots in the disk interrupt the light from the source on its path to the sensor intermittently as the motor shaft and disk rotate. The time between interrupts in the optical source/sensor path are measured by a microprocessor in the motor controller and compared with the goal time for the selected motion profile, as this time corresponds to the velocity of the motor. As such, the microprocessor either increases or decreases the voltage provided to the motor, which increases or decreases the torque generated by the motor. This voltage adjustment allows the velocity of the swing to approach and/or match the goal velocity.

In various embodiments, the number of feedback samples per cycle will vary based on the geometry of the slotted disk as well as the magnitude of the motion profile. Because the swing system operates based upon the principle of a simple pendulum, the swing must effectively come to a stop at the endpoints of the motion path. As such, the velocity of the seat, despite an increase in voltage to the motor, deviates increasingly from the goal velocity as the swing nears the endpoints of the motion path. This deviation is read by the microprocessor as an increased time between interrupts such that when this deviation becomes significantly large (effectively equal to the negative value of the goal speed), the voltage supplied to the motor is reversed as is the resultant torque provided by the motor. In this manner, the velocity profile is held relatively constant as the swing moves back and forth along the motion path.

Various embodiments may include variations in the shape, material, construction method, and size of the base frame, swing arms, and seat structures. Various embodiments may also allow for variations in the design of the electronic components used in conjunction with the motor controller. For example, in one embodiment, the swing may include a user interface system that allows a user to select one of a plurality of motion profiles of the swing and a duration of the swinging motion. In various embodiments, the user interface may be adjusted by means of mechanical or electrical switches, and the user interface system may be mounted on the support structure. In addition, various embodiments of the swing include toys or music for entertaining a child seated in the swing.
BRIEF DESCRIPTION OF THE DRAWINGS

Having thus described various embodiments of the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 illustrates an infant swing according to various embodiments of the invention.

Figure 2 illustrates a diagram of a speed swing controller according to various embodiments of the invention.

Figure 3 illustrates an embodiment of a motor driving circuit according to various embodiments of the invention.

Figure 4 illustrates a diagram of a swing arc traveled by the swing according to various embodiments.

Figure 5 is an encoder waveform recorded by an oscilloscope indicating generally the characterization of the pulse train according to various embodiments.

Figure 6 illustrates an expanded view of the encoder waveform of one half of the swing cycle shown Figure 5.

Figure 7 illustrates a flow diagram of a software algorithm executed by the controller shown Figure 2 according to one embodiment of the invention.

Figure 8 illustrates a flow chart of the Feedback Swing Control subroutine called in step 511 of Figure 7 according to one embodiment of the invention.

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS OF THE INVENTION

Various embodiments of the invention are described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown in the figures. Indeed, these inventions may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements.

Figure 1 illustrates one embodiment of the invention. As shown, an infant swing includes a seat that is mounted to a pair of swing arms that are pivotally mounted to the right and left apexes of a base frame, typically referred to as an "A" frame, in which the base, in profile view
appears to be an "A" or inverted "V" shape. Further, as there is no fixed, rigid member transversely mounted to the right and left apex, the frame style is referred to as an "open top". Although shown with a particular type of swing, various embodiments of the invention could include other swing types, such as glider swings.

Figure 2 illustrates a diagram of a speed swing controller according to various embodiments of the invention. The swing speed controller includes: a 6V direct current (DC) power supply, a DC motor, a speed-reducing system (e.g., transmission), a speed sensing system, and an electronic control unit. The DC power supply can be alkaline battery, rechargeable battery, or 6V, DC output from an AC-DC power converter plugged into an 110V wall outlet. The speed-reducing system transfers the motor power to the swing to mobilize the swing in a fore and aft direction. In one embodiment, the transmission includes a speed-reduction gear-set.

The speed sensor system provides a means to measure the swing speed and output an electrical signal representative of the swing speed. In one embodiment, the speed sensor system comprises an optical sensor and an encoder wheel. The optical sensor includes a light source and a photodiode. The output signal of the photodiode corresponds to the swing speed information, and this output signal is input to the electronic control circuit. In one embodiment, the encoder wheel is installed directly to one end of the motor shaft. However, in an alternative embodiment, the encoder wheel is mounted on the swing shaft to directly measure swing speed. In addition, in other embodiments, the speed sensor system includes other types of sensors, such as magnetic sensors, for example.

According to various embodiments, the electronic control circuit block includes a microcontroller, a motor driving circuit, a speed setup circuit, and a low voltage detector. The microcontroller may be chosen from any of a number of available, 8 bit micro-controller commercial products which include a central processing unit (CPU), a read only memory (ROM) in which to store the software program, a random access memory (RAM) and input/output (I/O) ports.

Figure 3 illustrates an embodiment of the motor driving circuit, which interfaces with the DC motor. In the embodiment in Figure 3, the motor driving circuit is implemented using an H-bridge circuit that has four switches, transistors, or other means of completing a circuit so as to drive the DC motor. The switches are labeled A, B, C, and D in Figure 3. Each of the four switches can be either open or closed, resulting in a total of sixteen possible switch settings. Table 1 below lists three combinations that are useful in one embodiment of the invention. By
controlling the switches on/off in different combinations, the DC motor can be driven forward or backward or allowed to freewheel to mobilize the swing in accordance with the desired operation.

<table>
<thead>
<tr>
<th>Switches</th>
<th>Polarity</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>A &amp; B</td>
<td>forward</td>
<td>motor spins forward</td>
</tr>
<tr>
<td>C &amp; D</td>
<td>reverse</td>
<td>motor spins backward</td>
</tr>
<tr>
<td>None</td>
<td>Free</td>
<td>motor floats freely</td>
</tr>
</tbody>
</table>

Table 1. The combination of the switches for motor driving

The speed setup circuit allows a user to input the desired swing speed. For example, in one embodiment, the speed setup circuit includes six speeds and an “off” position that can be selected by the user. By using the hardware components identified above, the speed controlled swing can swing at one of six speeds selected by the user.

A low voltage detector circuit is also implemented with the speed setup circuit to monitor the voltage of DC power supply when battery powered. The low voltage detection functions as an electronic switch, and once the power supply voltage drops below a predetermined level, the low voltage detector shuts down the DC power supply.

Figure 4 illustrates a diagram of the swing arc traveled by the swing according to various embodiments. Points M and N represent the highest swing positions, and the swing speed approaches zero at these points. Point Q represents the point at which the swing is perpendicular with the ground line, and the speed of the swing is greatest at this point in the swing arc. According to one embodiment, the motor shaft is driven through at least one full swing cycle (from M to N and back to M), and then the motor is allowed to rotate freely through at least one half of the next swing cycle. In one embodiment, the motor is driven by pulse width modulation (PWM) for one full cycle and is then allowed to free-wheel for a half swing cycle. Alternatively, the motor can be driven by PWM for a half swing cycle and allowed to free wheel for another half cycle or be driven by PWM for one and a half swing cycles and free-wheel for the next half cycle.
The swing speed is measured at the point at which the swing is perpendicular to the ground line, represented by Point Q, when the motor is free-wheeling, according to one embodiment. The speed measurement and characterization is carried out by the speed sensor system. According to the embodiment shown in Figure 5, the output of the speed sensor system is a series of pulses or “pulse train” that contain the swing speed information. The pulses are represented by output signals from the sensor resulting from the rotation of the encoder wheel relative to the sensor. Because the encoder wheel rotates proportionally to the swing, the pulses output by the sensor correspond to the movement of the swing. In one embodiment, the teeth of the encoder wheel are evenly distributed, and the pulse widths of all pulses are the same in the entire pulse train if the swing runs at a constant speed. However, as the swing moves from speed zero (points M or N) to maximum speed (point Q) and returns to zero (points N or M), the pulse width varies proportionally to the swing speed. This variation provides the opportunity to acquire the swing speed information. In particular, in one embodiment, the pulse width is measured when the photodiode output is at logic low (e.g., less light is received by the photodiode because slots extending from the encoder wheel prevent the transmission of light from the light emitter to the photodiode).

Figure 5 is an encoder waveform recorded by an oscilloscope indicating generally the characterization of the pulse train according to various embodiments. The time between the two widest pulses represents the half cycle of the swing traveling from points M to N in Figure 4. Figure 6 illustrates an expanded view of the encoder waveform of one half of the swing cycle shown Figure 5 between the time duration of 50-100ms. This expanded view more clearly

The micro-controller can determine swing cycles by continuously measuring motor speed. When the swing oscillates upward and is acted on by gravitational force, the swing speed begins to slow down and approaches zero speed. As the swing speed approaches zero at the top of its trajectory, the control circuit can react to the monitoring device’s corresponding signal and reverse the direction of the transmission motor. Furthermore, when the swing travels downward, its speed increases from zero to a maximum value, and the monitoring device continually transmits this corresponding speed signal to the control circuit. The control circuit processes the monitoring device’s speed signal continuously and when that speed value reaches a maximum, the control circuit can compare the value to a set-up maximum value and adjust the transmission motor’s output accordingly. By measuring swing speed and controlling the rotating shaft that
drives the oscillating swing seat, the control circuit can drive the swing uniformly and continuously in both directions.

The swing speed information is represented by the shortest pulse width of a half swing cycle, and this information is received by the micro-controller as feedback information. Based on this information, the micro-controller regulates the PWM, which controls the current of the motor driving circuit, thus increasing or decreasing the motor torque delivered to the swing to maintain the selected swing speed. By this means, the swing is able to achieve and maintain the preferred motion under a variety of loads, as determined by the weight of the occupant.

Figure 7 illustrates a flow diagram of a software module executed by the controller shown in Figure 2, according to one embodiment of the invention. The module 501 begins at step 502 by setting up input/outputs (I/O), resetting variables, and clearing counters. Next, in step 503, the input port is read, which contains the speed setup information to be checked in step 504. If the speed setup is 0, there is no action needed, and the module 501 keeps reading this input port and runs the loop between steps 503 and 504. Once the speed setup changes to any value among 1 to 6 (each of these values corresponding to each of a plurality of selected speeds or amplitudes for the swing), the program proceeds to step 505 and calls subroutine Swing_Drive-1. Subroutine Swing_Drive 1 produces moderate motor drive force. In step 506, the motor speed will be checked to see if it reaches 0. If the motor speed is 0, in step 507, the motor will reverse spin direction to run for another half cycle. When finishing the second half cycle drive, the motor is then allowed to free wheel for a half cycle, as shown in step 509. In step 510, the maximum swing speed is measured. Following Step 510, the Feedback Swing Control subroutine is executed as shown in step 511 to maintain the expected setup swing speed.

Figure 8 illustrates a flow chart of the Feedback Swing Control subroutine called in step 511 of Figure 7. The swing close loop control is implemented in this program. In step 521 the measured swing speed is compared with the user setup speed. If the measured swing speed is faster than the user setup speed, subroutine Swing_Drive-3 is executed in step 523. If the measured swing speed is slower than the user setup speed, step 522 is executed. Subroutine Swing_Drive-3 provides a relatively low volume of motor current, and subroutine Swing_Drive-2 provides a relatively heavy volume of motor current. The volume of the current provided by subroutine Swing_Drive-1 is between the current provided by Subroutine Swing_Drive-3 and Subroutine Swing_Drive-2. Next, the motor drives the swing for two half cycles, as shown in...
step 524, and then the motor is allowed to free wheel for a half cycle, shown in step 525. During this free-wheeling half cycle, the maximum swing speed is measured, as shown in step 526. After measuring the maximum speed, the speed setup is rechecked in step 527 to see if the user changes it. If the speed setup changes to 0, the subroutine returns to the main program.

CONCLUSION

Although this invention has been described in specific detail with reference to the disclosed embodiments, it will be understood that many variations and modifications may be effected within the spirit and scope of the invention as described in the appended claims.
FIG. 1
FIG. 2
FIG. 4
Swing Encoder Wave Form

Voltage (V)

Time (msx100)

FIG. 5
Swing Encoder Wave Form

FIG. 6
FIG. 7

START

501

Initialization: Setup I/O, Reset Variables and Clear Counters

502

2 Half Cycle Drive Done?

508

YES

509

Motor Free Wheel for one half cycle

510

NO

503

Read the Speed Setup Parameter

504

Speed Setup = 0

505

Subroutine: Swing_Drive-1

506

Motor Speed = 0?

507

Reverse Motor Spin Direction

507

NO

506

YES

505

Subroutine: Feedback Swing Control

511

Measure the Maximum Swing Speed

510

Return from Feedback Swing Control
FIG. 8

Subroutine: Feedback Swing Control

YES

Measured Swing Speed > Setup Speed?

Subroutine: Swing_Drive-2

Subroutine: Swing_Drive-3

NO

Drive Swing for 2 Half Cycle

Motor Free Wheel for one half cycle

Measure the Maximum Swing Speed

NO

Speed Setup = 0?

YES

Return
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The present invention is advantageous over existing art as it describes a feedback system which provides a consistent motion profile under any loading condition as well as smoother velocity profile over the motion path. As the primary function of the swing is to produce calming motion, a steady velocity over the entire motion path is desired as it produces a smoother and gentler motion thus resulting in a more calming effect than the swinging motions presented in existing art. The present invention also allows for a plurality of motion profiles, as selected by the user and produced by comparing the present velocity of the swing to the unique goal velocity for any preprogrammed motion profile independent of the angle of travel by the pendulum or its direction.

**Summary of Invention**

The present invention concerns the motor system producing the rocking motion in an infant or child swing and more specifically, concerns the motor control system which regulates motion path of the swing. The swing consists of a base frame which rests on the ground and having a plurality of uprights extending from such. A plurality of swing arms are pivotally mounted to the uprights of the base frame at one end and to a seat, pivotably or not, at the other, typically having one arm supporting on either side of the seat. A DC motor is affixed to the support frame such that the motor shaft can provide a torque to one or more swing arms about the arm/upright connection point.

The motor system consists of the DC motor, voltage supply and the motor controller, which is used to regulate the voltage supplied to the motor. Motor feedback is provided by a light interrupter detector consisting of a slotted disk and an optical source/sensor. The slotted disk is mounted either directly to the motor shaft or indirectly as by a gear box or the like. The optical source and sensor are positioned such that the slots in the disk interrupt the light from the source on its path to the sensor intermittently as the motor shaft and disk rotate. The time between interrupts in the optical source/sensor path are measured by the microprocessor in the motor controller and compared with the goal time for the selected motion profile, as this time is directly related to the velocity of the motor. As such the microprocessor either increases or decreases the voltage provided to the motor and as a result, the torque generated by the motor such that the velocity of the swing is maintained near the goal velocity. The number of feedback samples per cycle will vary based on the geometry of the slotted disk as well as the magnitude of the motion profile. Because the swing system operates based upon the principle of a simple pendulum, the swing must effectively come to a stop at the endpoints of the motion path. As such, the velocity of the seat, despite an increase in voltage to the motor, deviates increasingly from the goal velocity as the swing nearing the endpoints of the motion path. This deviation is read by the microprocessor as an increased time between interrupts such that when this deviation becomes significantly large (effectively equal to the negative value of the goal speed), the voltage supplied to the motor is reversed as is the resultant torque provided by the motor. In this manner the velocity profile can be held relatively constant as the swing moves back and forth along the motion path.

The invention allows for a variation in the number, shape, material, construction method and size of support structure as well as in the swing arms and seat attached to it. The invention also allows for variations in the design of the electronic components used in conjunction with the motor controller. Notably, the swing may include a user interface system, preferably mounted on the support structure, allowing for the selection of the motion profile of the swing and duration of the swinging motion which can be adjusted by means of switches, whether mechanical or electronic in nature. The invention can further incorporate toys or music with which to entertain the child. While
Detailed Description of Invention

The preferred embodiment of the invention is shown in FIG. 1. It is an infant swing in which a seat is mounted to a pair of swing arms, which in turn, are pivotally mounted to the right and left apices of a base frame, typically referred to as an "A" frame, in which the base, in profile view appears to be an "A" or inverted "V" shape. Further, as there is no fixed, rigid member transversely mounted to the right and left apex, the frame style is referred to as an "open top". Although shown with a particular type of swing, the invention could be used in other swing types also, such as glider swings.

FIG. 1

The speed swing controller comprises a 6V direct current (DC) power supply, a DC motor, a speed-reducing system (aka: transmission), a speed sensing system and an electronic control unit. Its diagram of this embodiment is shown in FIG. 2. The DC power supply can be alkaline battery, rechargeable battery, or 6V, DC output from an AC-DC
power converter plugged into an 110V wall outlet. The speed-reducing system is for transferring the motor power to mobilize the swing in a fore and aft direction. In the preferred embodiment, the transmission consists of a speed-reduction gear-set.

The purpose of the speed sensor system is to provide a means to measure the swing speed and output an electrical signal representative of the swing speed. In the preferred embodiment, the speed sensor system comprises an optical sensor, but magnetic sensors and other types of sensors are readily available as well. The optical sensor includes a light source, an encoder wheel and a photodiode. The output signal of the photodiode which represents the swing speed information will be the input to the electronic control circuit. In this embodiment, the encoder wheel is installed directly to one end of the motor shaft but alternatively can be mounted on the swing shaft in order to directly measure swing speed.

The electronic control circuit block includes a micro-controller, a motor driving circuit, a speed setup circuit and a low voltage detector.
A micro-controller can typically be chosen from any of a number of available, 8 bit micro-controller commercial products which include a central processing unit (CPU), a read only memory (ROM) in which to store the software program, a random access memory (RAM) and input/output (I/O) ports.

A motor driving circuit interfaces with the DC motor and is implemented using an H-bridge circuit. In this embodiment, the H-Bridge has 4 switches, transistors or other means of completing a circuit so as to drive the DC motor. FIG. 3 shows that the switches are labeled A, B, C and D. Each of the four switches can be either open or closed, therefore having a total of 16 possible switch settings. There are three combinations that are useful in the preferred embodiment and are listed in Table 1. By controlling the switch on/off in different combinations, the DC motor can be driven forward, backward or freewheel in order to mobilize the swing in accordance with the desired operation.

![H-Bridge diagram](attachment:image.png)

**FIG. 3**

<table>
<thead>
<tr>
<th>Closed switches</th>
<th>Polarity</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>A &amp; B</td>
<td>forward</td>
<td>motor spins forward</td>
</tr>
<tr>
<td>C &amp; D</td>
<td>reverse</td>
<td>motor spins backward</td>
</tr>
<tr>
<td>None</td>
<td>Free</td>
<td>motor floats freely</td>
</tr>
</tbody>
</table>

Table 1. The combination of the switches for motor driving

A speed setup circuit allows a user to input the desired swing speed. This embodiment includes 6 speeds and an “off” position which can be user selected. A low voltage detector circuit is also implemented so as to monitor the voltage of DC power supply when battery powered. The low voltage detection functions as an electronic switch.
Once the power supply voltage drops below a predetermined level, the low voltage detector shuts down the DC power supply.

By using the hardware components identified above, the speed controlled swing can swing at one of six speeds selected by the user. The swing speed is measured at the point the swing is perpendicular to the ground line, represented by Point Q (see FIG. 4) when the motor is free-wheeling. In this embodiment, the motor shaft rotates freely through one half of the swing cycle in order to obtain information as to the current swing speed. A full swing cycle is defined as the swing travels from point M to point N and then returns to M. Point M and N each represent the highest swing position whereupon the speed of the swing approaches zero. In this embodiment, the motor is driven by pulse width modulation (PWM) for one cycle and is then allowed to free-wheel for a half swing cycle. Alternatively, the motor can be driven by PWM for a half swing cycle and allowed to free wheel for another half cycle or be driven by PWM for 1.5 half cycles and free-wheel for another half cycle.

![Diagram](point_m_n_q_graph.png)

FIG. 4

The swing speed is measured and characterized by the speed sensor system. The output of the speed sensor system is a series of pulses or “pulse train” (see FIG. 5) which contains the swing speed information due to the fact that the encoder wheel rotates at the proportional to that of the swing. Because the teeth of the encoder wheel are evenly distributed, the pulse widths of all pulses are the same in the entire pulse train in the event that the swing runs at a constant speed. However, as the swing moves from speed zero to maximum speed and returns to zero, the pulse width varies proportionally to the swing speed. This variation provides the opportunity to acquire the swing speed information. The pulse width is measured when the photodiode output is at logic low. FIG. 5 is an encoder waveform recorded by an oscilloscope indicating generally the characterization of the pulse train. The time between the two widest pulses represents the half cycle of the swing traveling from M to N in FIG. 3. FIG. 6 more clearly differentiates the variation in pulse width by zooming in one half of the swing cycle between the time duration of 50-100ms in FIG. 5.
The micro-controller can determine swing cycles by continuously measuring motor speed.
When the swing oscillates upward and is acted on by gravitational force, the swing speed begins to slow down and approaches zero speed. As the swing speed approaches zero at the top of its trajectory, the control circuit can react to the monitoring device's corresponding signal and reverse the direction of the transmission motor. Furthermore, when the swing travels downward its speed increases from zero to a maximum value and the monitoring device continually transmits this corresponding speed signal to the control circuit. The control circuit processes the monitoring device's speed signal continuously and when that speed value reaches a maximum, the control circuit can compare the value to a set-up maximum value and adjust the transmission motor's output accordingly. It is by this way of measuring swing speed and controlling the rotating shaft that drives the oscillating swing seat that the control circuit is capable of driving the swing uniformly and continuously in both directions.

The swing speed information which is the shortest pulse width of a half swing cycle is received by a micro-controller as feedback information. Based on this information, the micro-controller regulates the PWM which controls the current of the motor driving circuit, thus increasing or decreasing the motor torque delivered to the swing in order to maintain the selected swing speed. By this means, the swing is able to achieve and maintain the preferred motion under a variety of loads, as determined by the weight of the occupant.

FIG. 7 demonstrates one of the implementations of software algorithm executed by the hardware depicted in FIG. 2. FIG. 7 is the flow chart of the main control software program. The software starts from 501 and the first task in step 502 is to setup I/O, reset variables and clear counters. Next, in step 503 the micro-controller reads the input port which contains the speed setup information to be checked in 504. If the speed setup is 0, there is no any action needed and the micro-controller keeps reading this input port and runs the loop between 503 and 504. Once the speed setup changes to any value among 1 to 6, the program proceeds to 505 and calls subroutine Swing_Drive-1 which can produce moderate motor drive force. In step 506, the motor speed will be checked to see if it reaches 0. If the motor speed is 0, in step 507 the motor will reverse spin direction to run for another half cycle. When finishing the 2 half cycle drive, the motor will be free wheel for a half cycle in step 509, and 510 is going to measure the maximum swing speed. After that the Feedback Swing Control 511 kicks in to maintain the expected setup swing speed.
FIG. 7

FIG. 8 presents the flow chart of feedback swing control subroutine called in step 511. The swing close loop control is implemented in this program. In step 521 the measured swing speed is compared with the user setup speed. If the measured swing speed is faster than the user setup speed, subroutine of Swing_Drive-3 (523) is executed. Subroutine Swing_Drive-3 (523) provides lower volume of motor current, whereas subroutine Swing_Drive-2 (522) provides heavy motor current. The volume of the current provided by subroutine Swing_Drive-1 is between the previous two. If the measured swing speed is slower than the user speed setup, step 522 is executed, otherwise step 523 is executed. The swing runs for 2 half cycle (524) and then there is a free wheel half cycle (525) to measure the maximum swing speed (526). After that, the speed setup is
Visit PatentFile.org for more examples of provisional patent applications rechecked in step 527 to see if the user changes it. If the speed setup changes to 0, the subroutine returns to the main program.

Subroutine: Feedback Swing Control

521 Measured Swing Speed > Setup Speed? YES

522 Subroutine: Swing_Drive-2

523 Subroutine: Swing_Drive-3

524 Drive Swing for 2 Half Cycle

525 Motor Free Wheel for one half cycle

526 Measure the Maximum Swing Speed

527 NO Speed Setup = 0? YES

Return

FIG. 8