14-733C2

# COLLISION MONITORING SYSTEM

## CROSS REFERENCE TO RELATED APPLICATIONS:

The present application is a continuation-in-part of application serial no. 09/562,986 filed May 1, 2000 which is a continuation-in-part of application serial number 08/736,786 to Boisvert et al. which was filed on October 25, 1996, now US patent no. 6,064,165 which was a continuation of united States application serial number 08/275,107 to Boisvert et al. which was filed on July 14, 1994 which is a continuation in part of application serial number 07/872,190 filed April 22, 1992 to Washeleski et al., now United States patent 5,334,876. These related applications are incorporated herein by reference. Applicants also incorporate by reference United States patent number 5,952,801 to Boisvert et al, which issued September 14, 1999. This application also claims priority from United States Provisional application serial no. 60/169,061 filed December 6, 1999 which is also incorporated herein by reference.

## FIELD OF THE INVENTION:

The present invention concerns motor driven actuator control systems and methods whereby empirically characterized actuation operation parameters are subsequently monitored.

## BACKGROUND:

National Highway Traffic Safety Administration (NHTSA) Standard 118 contains regulations to assure safe operation of power-operated windows and roof panels. It establishes requirements for power window control systems located on the vehicle exterior and for remote control devices. The purpose of the standard is to reduce the risk of personal injury that could result if a limb catches between a closing power operated window and its window frame. Standard 118 states that maximum allowable obstacle interference force during an automatic closure is less than 100 Newton onto a solid cylinder having a diameter from 4 millimeters to 200 millimeters.

Certain technical difficulties exist with operation of prior art automatic power window controls. One difficulty is undesirable shutdown of the power window control for causes other than true obstacle detection. Detection of obstacles during startup energization, soft obstacle detection, and hard obstacle detection each present technical challenges requiring multiple simultaneous obstacle detection techniques. Additionally, the gasket area of the window that seals to avoid water seepage into the vehicle presents a difficulty to the design of a power window control, since the window panel encounters significantly different resistance to movement in this region. Operation under varying power supply voltage results in actuator speed variations that result in increased obstacle detection thresholds.

<u>SUMMARY OF THE INVENTION:</u>

This invention concerns an improved actuator system that provides faster operation, more sensitive obstacle detection, faster actuator stopping with reduced pinch force, and reduced false obstacle detection all with less costly hardware. This invention has utilization potential for diverse automatic powered actuator applications including positioning of doors, windows, sliding panels, seats, control pedals, steering wheels, aerodynamic controls, hydrodynamic controls, and much more. One exemplary embodiment of primary emphasis for this disclosure concerns an automatic powered actuator as a motor vehicle sunroof panel.

An exemplary system built in accordance with one embodiment of the invention implements position and speed sensing is via electronic motor current commutation pulse sensing of the drive motor. Motor current commutation pulse counting detection means and counting correction routines provide improved position and speed accuracy.

In one exemplary embodiment, stored empirical parameter characterizations and algorithms adaptively modify obstacle detection thresholds during an ongoing actuation for improved obstacle detection sensitivity and thresholds resulting in quicker obstacle detection with lower initial force, lower final pinch force and reduced occurrences of false obstacle detection.

An exemplary embodiment of the collision sensing system uses a memory for actuation speed measurement, motor current measurement, and calculations of an ongoing actuation with real time adaptive algorithms enables real time running adaptive compensation of obstacle detection thresholds.

BRIEF DESCRIPTIONS OF THE DRAWINGS:

Figure 1 is a block diagram schematic of the components of an exemplary embodiment of the present invention;

Figures 2A – 2D are schematics of circuitry for controlling movement and sensing obstructions of a motor driven panel such as a motor vehicle sunroof;

Figure 3A is a plan view depicting an optical sensing system for monitoring an obstruction in the pinch zone of a moving panel such as a motor vehicle sunroof;

Figure 3B is a front elevation view of the Figure 3A optical sensing system;

Figure 3C is a plan view depicting an optical system with moving optics for monitoring an obstruction at the leading edge of a moving panel such as a motor vehicle sunroof;

Figure 3D is a front elevation view of the Figure 3C optical sensing system;

Figure 3E is a plan view depicting an optical sensing system with moving optics, flexible optic fiber, remote IR emission, and remote IR detection for monitoring an obstruction at the leading edge of a moving panel such as a motor vehicle sunroof;

Figure 4 represents typical startup energization characteristics of motor current and per speed versus time;

Figure 5 represents a simplified example of characteristic steady state nominal motor operation function versus time or position;

Figure 6 represents a simplified example characteristic dynamic transient motor operation function versus time and/or position showing motor operation function with transients;

Figure 7 represents a simplified example characteristic dynamic periodic cyclic motor operation function versus time and/or position showing motor operation function with cyclic disturbances; and

Figure 8 is a sequence of measurements taken by a controller during successive time intervals and operation of a monitored panel drive motor.

## BEST MODE FOR PRACTICING THE INVENTION:

Figure 1 shows a functional block diagram of an actuator safety feedback control system 1 for monitoring and controlling movement of a motor driven panel such as a motor vehicle sunroof. A panel movement controller 2 includes a commercially available multipurpose microcontroller IC (integrated circuit) with internal and/or external FIFO memory and/or RAM (Random Access Memory) 2a and ADC (analog-to-digital-converter) 2b.

Eight-bit word bytes, eight-bit counters, and eight-bit analog-to-digital conversions are used with the exemplary controller 2. It should be fully realized, however, that alternative word lengths may be more appropriate for systems requiring different parameter resolution. Larger word bytes with equivalent ADC resolution enables greater resolution for motor current sensing. Likewise, larger word bytes with higher microcontroller clock speeds enable greater resolution for motor per speed sensing plus quicker digital signal processing and algorithm processing for quicker response time.

A temperature sensor 3 (which according to the preferred embodiment of the invention is an option) when installed, is driven by and sensed by the controller 2. Temperature sensing allows the panel controller 2 to automatically sense vehicle cabin temperature and open or close the sunroof to help maintain a desired range of temperatures. Temperature compensation of actuator obstacle detection thresholds is typically unnecessary.

An optional rain sensor 4 can be both driven by and sensed by the microcontroller 2. Automatic closing of the sunroof panel occurs when the sensor is wet. Subsequently, the sunroof panel can be opened when either falling rain has stopped for some time duration or when the rain has evaporated to some extent.

Manual switch inputs 5 are the means by which operator control of the system occurs.

Limit switch inputs 6 indicate to the control system such physical inputs as HOME position, VENT/NOT OPEN Quadrant Switch, and end of panel movement. Limit switch signals indicate where microcontroller encoder pulse counter registers are set or reset representative of specific panel position(s).

Motor drive outputs 7a and 7b control whether the motor drives the panel in the forward or the reverse direction. When neither the forward nor the reverse direction are driven, the motor drive terminals are electrically shorted together, possibly via a circuit node such as COMMON, resulting in an electrical loading and thus a dynamic braking effect.

Motor plugging drive, which is the application of reverse drive polarity while a motor is still rotating, is an optional method of more quickly stopping the motor, but has been unnecessary for use with the preferred embodiment of the sunroof panel controller due to satisfactory performance taught by this disclosure. Very large motor plugging currents are often undesirable because they can easily exceed typical maximum stalled rotor currents producing undesired motor heating in large applications. Such high motor plugging currents can be detrimental to the life and reliability of electromechanical relay contacts and solid state switches used to switch motor operating currents. High motor plugging currents can also cause undesirable transients, trip breakers, and blow fuses in a power supply system.

Application of brakes and/or clutches is also unnecessary with the automotive sunroof system due to the improved real time obstacle detection performance taught by this disclosure.

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