Safety features for an automated retractable car roof design

Group: 21 B

RATIONALE FOR SAFETY FEATURES IMPLEMENTED

The objective of this safety features is to ensure safe operation of the retractable car roof. Appropriate safety measures in automated system should ensure that potential risks for injuries is at zero. The addition of the retractable roof to the car also lead to an exposure of risk with regards to passenger's safety, advancement of safety features becomes important. This can be achieved by integrating safety features using sensors. These safety features will prevent accidents and injuries caused by the deployment and retraction process of the roof and preventing damage to the roof mechanism.

Safety Feature 1: Automatic Stop

Emergency stop is commonly used as a safety feature in automation if an unsafe condition is observed. This safety feature acts as an automated fail-safe measure to detect any obstruction when the roof is in motion and immediately stops the mechanism by removing power in the actuator. Obstructions during roof operation such as passenger's body part can cause mechanism failure and cause injury to the passenger. For instance, if a passenger's arm is in the way of the roof's path of operation, the retractable roof continue deployment process and it generates force that can cause severe injury to the passenger.

Safety Feature 2: Speed Sensor

The roof can only operate when the car is moving under 30 km/h speed. At a higher speed, the vehicle body will experience air resistance, which is a major source of drag. Attempting to retract or deploy the roof above the speed limit may result in operation failure, therefore it is a risk to passenger's safety. The roof will only be able to operate when the car is at a stop or moving under 30 km/h speed, this integrated sensor will detect if the car is moving above 30 km/h and cease the operation.

Safety Feature 3: Overhead Clearance Detection

When deploying, the roof has maximum height of 65 cm. When the car goes through basement parking, overpasses and other road construction work platforms, vertical clearance is reduced therefore might pose over height impact when trying to operate the roof. These accidents can cause physical damage to property and to the roof itself therefore can result in damage to passenger in the vehicle. The sensor integrated in this safety feature will detect if overhead clearance is safe for roof to continue operation.

DESCRIPTION OF OPERATION

Safety Feature 1: Automatic Stop

During the operation of the roof, when an object is detected at any position, the controller will immediately stop the deployment process by stopping the motor. When there is an obstruction in the roof's path, the roof will still try and continue moving forward and this will result in increase on output torque of the motor, that is proportional to decrease in motor speed. Sensor is located on the rotor of the motor, and

a magnetic target is mounted on the stator. The sensor check changes in rotation speed of the motor. The sensor detects when speed drops below 61.98 rad per second, which is the average rotating speed of the motor in normal operation. Microcontroller continually checks the status of the input port and the signal is LOW (0 Volts) when in neutral, when the sensor detects drop in motor speed, the signal will be HIGH (5 Volts) and turns off the motor.

Safety Feature 2: Speed Sensor

Mounted on the side of the wheel axle, with magnetic target attached to the vehicle, magnetic speed sensor detects change in magnetic field, proportional to the speed of the target. As target near the sensor's sensing area changes the flux lines of the magnetic field and changes its strength. The analogue sensor measures when wheel axle goes above angular speed of 368 rpm and sends signal to the microcontroller to turn off the motor.

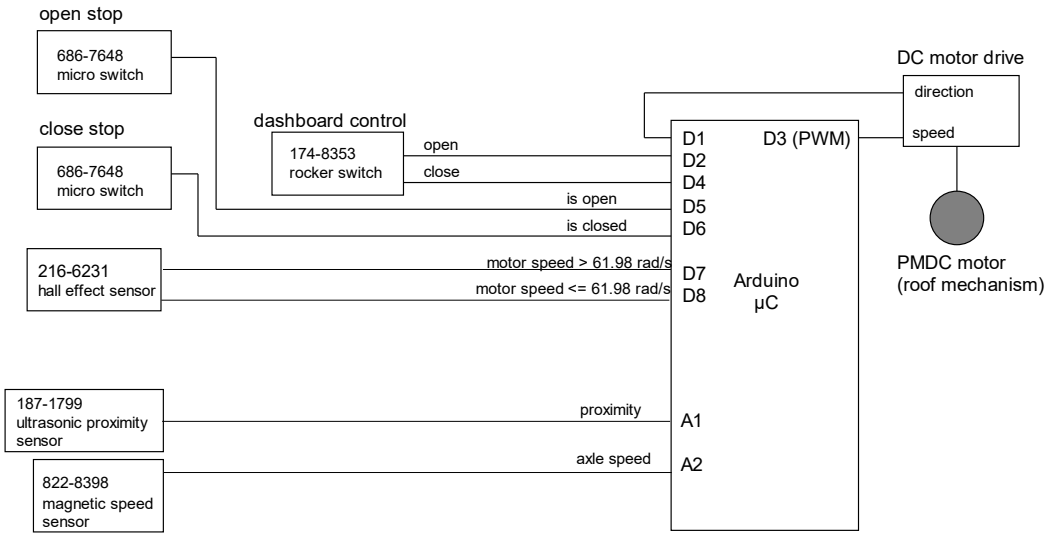
Safety Feature 3: Overhead Clearance Detection

An ultrasonic proximity sensor is mounted to the latching part of the roof above the car's windshield. The sensor detects if there is an object above the car and detects its proximity. The maximum swept height of the roof during operation is 65 cm, the sensor will detect if there is an object within 80 cm above, giving leeway for safe operation. The sensor uses ultrasonic technology that gives analogue signal measuring proximity of the overhead obstruction, when the sensor detects an object within 80 cm above, the microcontroller sends signal to turn off the motor.

SENSORS

RS Catalogue Number	Description	Image
216-6231	Hall effect sensor	
822-8398	Magnetic speed sensor	
187-1799	Ultrasonic proximity sensor	

HARDWARE SCHEMATIC DIAGRAM



Notes
1. part numbers from RS catalogue
2. D1 == true (output) opens the roof
3. D2,D4,D5,D6,D7,D8,A1,A2 configured as input ports
4. D3 used for PWM output (PWM 3)

Automated car roof hardware schematic			
Drawing 1 of 1		not to scale	
Checked SS	Version 2	Date 23 Apr 2022	For UoB

MICROCONTROLLER EMBEDDED SOURCE CODE

```
/*
 * Automated car roof embedded controller code
 *
 * refer to hardware schematic for port assignment
 * Author: SS
 * Version: 2
 * Date: 27/4/2022
 */

void setup() {
  // configuring pin as input/output
  pinMode (1, OUTPUT);
  pinMode (2, INPUT);
  pinMode (4, INPUT);
  pinMode (5, INPUT);
  pinMode (6, INPUT);
  pinMode (7, INPUT);
  pinMode (8, INPUT);
  pinMode (A1, INPUT);
  pinMode (A2, INPUT);
  Serial.begin(9600); //Serial Communication is starting
with 9600 of baudrate speed
```

```
}
//setting analog sensors parameters
int paramProximity = 80;
int paramSpeed = 368;
int valProxParam = (paramProximity-7/(100-7))*1023;
int valSpeedParam = (paramSpeed/1000)*1023;

void loop() {
//opens roof when switch is pressed to open
  if(digitalRead(2) == HIGH){
    digitalWrite(1, HIGH);
    analogWrite(3, 255);
  }
//closes roof when switch is pressed to close
  if(digitalRead(4) == HIGH){
    digitalWrite(1, LOW);
    analogWrite(3, 255);
  }
 //turns off the motor if end stop is reached, or if
obstruction is detected, or if car is moving above safe
operation speed limit, or if overhead clearance
insufficient
  if(digitalRead(5) == HIGH || digitalRead(6) == HIGH ||
digitalRead(8) == HIGH || analogRead(A1) < valProxParam
|| analogRead(A2) > valSpeedParam){
    analogWrite(3, 0);
  }
}
```