

# The Design on Attitude Control System for the car falling into the water

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**Abstract:** With the widespread use of automobiles, people's demand for the safety performance of vehicles is also increasing. Nowadays, all kinds of safety technology and equipment are widely used in automobile, such as safety belt, safety seat, air bag and so on. However, the safety performance of a car that falling into the water is rarely considered. Once the car fell into the water and was flooded accidentally, it will be very difficult for passenger to survival which will result in enormous loss of life and property. Aimed at this problem, this paper presents a particular solution. The design on attitude control system can correct the attitude of the car and let it float when the car falling into the water. After being rescued successfully, the car can travel normally after a careful examination and simple maintenance .

**Keywords:** attitude control system ;vehicle passive safety ;airbag ; multi-sensor

## I. INTRODUCTION

The system is composed of acceleration sensor, water pressure sensor, attitude sensor, control device, airbag module, air bag indicator, mode selector switch. The control device receives the signals from acceleration sensor, water pressure sensor and attitude sensor then determine the status of the car and decide whether to trigger the airbag. The air bag indicator is used to indicate the system fault and as a light warning when the car was drowning in the rain. The mode selection switch is used to select the system mode.

If the system is in manual mode, When the car faced with the danger of being submerged, the passenger can turned on the switch in order to trigger the gas generator and let airbag pop up quickly.

If the system is in automatic mode, when the water rises to a certain height the pressure sensor detects the water level signal and transmitted to the control device. Control device determine whether there is a risk of being flooded and whether to trigger gas generator.

If the car fall from a great height when When running , the acceleration sensor will collect the signal to the control device and identify that the car is falling. The acceleration signal will change when the vehicle touch the surface of the water and at the same time the hydraulic pressure sensor will test the water pressure then transmit the signal to the control device. The control device will conclude that the car is falling into water on account of acceleration signal pressure signal. The posture sensor test attitude signal and the control device conclude that which airbag should be opened. Ten The car keeps the level under the action of buoyancy force.

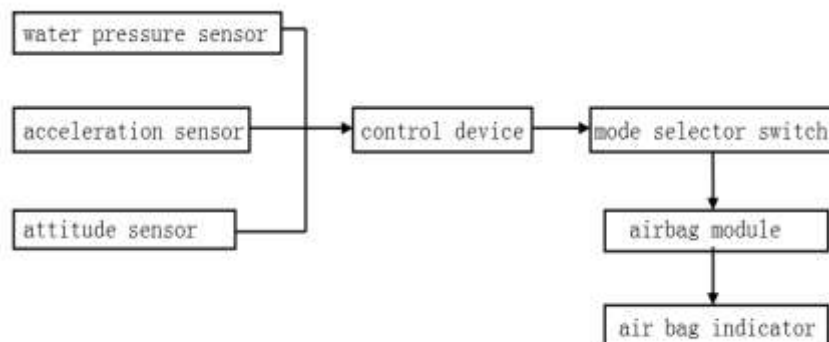


Fig. 1 system frame diagram

## II. CONCRETE STRUCTURE

### 2.1 Acceleration sensor

In order to ensure that the acceleration of the measurement is accurate, the vertical acceleration sensor should be located in the center of the car, generally under the driver's seat. When the vertical acceleration is acting on the vehicle, the permanent magnet will have relative movement which will be delayed due to the inertia. This movement will produce eddy current in the damping plate then produce a magnetic field which opposite to the permanent magnet. So the strength of the total magnetic field is weakened. This will change the voltage of the Holzer sensor. The change of voltage reflects the vertical acceleration of the vehicle.

### 2.2 Water pressure sensor

Water pressure sensor is the main control signal of the control device system. It is used to detect the strength signal of hydraulic and transmit it to the control device. The control device determine whether there is a need to open the airbag. Water pressure sensor is placed in the four place of the car: below the radiator, above the radiator, below the rear suspension and above the radiator rear suspension. The position of water pressure sensor will have great influence on the function of the system, for example, it will cause unnecessary trigger if the sensor is too close to the ground. So we must choose the best position through many experiments.

### 2.3 attitude sensor

Vehicle attitude position sensor detect vehicle attitude after falling into water. The attitude position signal will be transmitted to control device to determine the best program to open air bag. The vehicle attitude position sensor is located in the center of vehicle. Attitude sensor is a high performance 3D motion attitude measurement device based on MEMS technology. It contains three axis gyro, three axis accelerometer, three axis electronic compass and other motion sensors. It can get 3D pose and orientation data that temperature compensated by embedded low power ARM processor. Then the processor can output zero drift 3D pose data based on the four dimensional algorithm and the special data fusion technology.

### 2.4 airbag module

The airbag module is mainly composed of an air bag, a gas generator and an ignition device.

#### 2.4.1 air bag

After falling into the air, the air bag is inflated to form a certain volume of space. As long as there is sufficient drainage volume, it can generate enough buoyancy to float the car. The air bag is composed of a film with a certain physical mechanical characteristic which has special shape. In order to allow all the gas into the bag, the bag and the gas generator is connected with gas outlet. The air bag has a plurality of air chambers. All the air chambers are connected to each other so as to ensure that all the gas chambers can get gas from the gas generator. A certain connecting rib should be arranged inside the air bag to maintain the shape of the air bag after it is inflated. Air bag should not only have reliable sealing, but also can adhere to a certain time, so that the car has enough time to float.

There are 11 airbag modules are located at roof, bumper, door, front wheel and rear wheel. The bag on roof can provide torque when car is floating so as to control the attitude of vehicle. The other 10 airbags provide buoyancy to the car. In order to ensure that the airbag is opened and has a good effect, the installation position of the airbag module meets the following requirements:

(1) installed near the deep of car body. If not, the car will be completely submerged in the water when the air bag is opened and the maximum buoyancy is generated. This is a bad situation which is not conducive for the occupants to escape and also caused some damage to car.

(2) The weight of front axle and rear axle of vehicle are different, therefore, the installation position must ensure buoyancy can maintain the level of the car.

Airbag parameters: Take the car of 1.5T as an example, buoyancy of air bag is  $1.5 \times 10^4$  N, the volume of water is  $1.5\text{m}^3$ , the weight of water is  $1.5 \times 10^4$  kg, so the volume of air bag underwater is  $1.5\text{m}^3$ . In order to ensure a good floating effect, the volume of the airbags is  $2\text{m}^3$ , the volume of the one airbag is  $2\text{m}^3$ .

#### 2.4.2 Gas generator

Gunpowder gas generator was used in the system. The gas generator is mainly used for producing a large amount of gas rapidly and inflate the air bag. Important characteristics of gas generators including the amount of gas produced per unit time, temperature, pressure and total amount of gas. When the central controller sends out the ignition instructions, the ignition agent will be detonated in the ignition, the ignition agent will generate a large amount of heat, the air charging agent is heated to release nitrogen immediately, and the air bag is inflated.

## **2.5 control device**

The task of system's control device is to accept the acceleration signal from the vertical acceleration sensor, pressure sensor pressure signal and the attitude sensor attitude signals, judge vehicle condition, control the airbag module trigger system. The control device is the core of the airbag system, which controls the ignition of the airbag system and makes the system fault diagnosis. Sensor used to detect the size of the pressure of the car, it will receive the signal and transmit it to the control system. The control device determines whether or not the air bag is to be started by calculating and analyzing the signal of the sensor. It also can choose different solutions to open air bag according to different pressures. If the pressure of the car reaches a certain degree, the starting condition is reached, and the electronic control system sends out the starting signal to the trigger device. The trigger device receives will trigger the gas generator after received signal, then the air bag enters the working state.

## **2.6 mode switch**

This switch uses a general spring type switch. Through the mode switch can select the system to open or close, you can also choose the mode of operation for automatic or manual. Manual mode is set to prevent the failure of the system when the system fails to open the airbag. In manual mode, the air bag ignition device can be triggered directly. In order to prevent misuse, manual switch has a protection device

# **III. CONTROL LOGIC**

## **3.1 flooded by the rain**

When car is in normal running (or stop), it is in a horizontal state. Once faced with water conditions (or slow rise), the system will think it's safe before the water pressure sensor touch the water surface. In spite of a drop of water on the water pressure sensor, the system will not make a mistake because there is no water pressure. When the water continued to rise and touch the bottom of the two pressure sensor, control device judgment that there is a risk of being flooded through detecting the acceleration sensor and attitude sensor then prompt the crew to leave the car by flashing air bag indicator light and playing voice warning. When the water level continues to rise and reaches the top of the water pressure sensor, this is a limit position. Under these circumstances 10 airbags will be opened at the same time. Of course, if the crew believes that the situation is urgent they can also choose the manual mode, and then open the airbag directly.

## **3.2 Falling from a height into the water**

First of all to determine the process of falling into the water. In the normal course of travel, the car out of the road (node one), fall and hit the surface of the water (node two), then into the water quickly due to the inertia. When the body first reaches its lowest point (node three), although the body has been drowned, the water can not enter the car in a short time because of the good closeness of the car. So the car will float due to the effect of buoyancy.

### **3.2.1 the process of falling into the water**

#### **(1) node 1: out of the road**

At this time, the acceleration sensor detects the change of the vertical acceleration, the attitude position sensor detects the change of the vehicle attitude but water pressure sensor does not detect the change of water pressure. Therefore, the control device think that the car is falling from a height and it is possible to fall into the water. At the same time, the control device will transmit the relevant information to the safety belt tightening system.

**(2)node two:** impact surface of water

The car hit the surface of water and the acceleration sensor detects the drastic change of the acceleration value then the control device judges the car has been impacted. However, the collision sensor of the automobile safety airbag has not detect the collision signal. And, the pressure sensor detects the pressure signal in a very short time. Therefore, the control device determine the car is falling into the water from a height place. Attitude sensor will increase the frequency of testing and transmit it to the control device.

**(3)node three:** lowest point

The acceleration changes again, the water pressure sensor detects the maximum value, the attitude sensor detects the change of the attitude of the vehicle, the control device judge the car is in the lowest point, the next step will go up.

### **3.2.2 rising process**

Between the node three to node four is the floating process. During the process of rising, the control device will compare the signals detected by the sensors with the preset program, and control the opening of the air bag. At the same time, the control device judges the attitude of the vehicle according to the real-time attitude information transmitted by the attitude sensor, and calculates the position the air bag, the opening sequence, the timing and the charging speed.

#### **Program 1**

The body is facing upward. This is the most ideal situation. In this ideal situation, the top attitude control air bag does not need to be opened. The controller judges whether the vehicle is in a horizontal state according to the attitude signal from the attitude sensor. If the car is in a horizontal state, the 10 airbags open at the same time, the car is not affected by buoyancy and continue to maintain the level of attitude, then float to the surface of water.

#### **Program 2**

The body tilt, for the more ideal situation. If the body is tilted to the left, in this case, the top air bag will open to ensure that the body can restore the level of attitude as soon as possible. Due to the torque generated by the buoyancy, the body rotates to the right and restore the positive upward Gradually. 4 buoyant air bags on the left side of the body will open when the body is facing up. Because of the buoyancy force, the vehicle restores the horizontal attitude. Then 4 buoyancy airbags on the right side and 2 air bag of front and back will open then the car float up to the surface of the water level.

#### **Program 3**

For the most unsatisfactory situation, the car flipped over in water. In this case, in order to generate the buoyancy force to restore the body in a level of attitude, the buoyancy bag on the right side of the body should be opened first. The body will inclined to the right because of the action of the torque. Then open the attitude control airbag on the top of the body to generate the right moment. When the car is going to flip, open the air bag on the left side of the car, the body will recovery level under the action of the moment of buoyancy, and then open the front and rear buoyancy bag. At this point, the body has been rotated for a week, the body floating in the horizontal state.

## **IV CONCLUSION**

This paper begins with the passive safety devices on the car, and leads to a new type of passive safety device which is not yet available on the car. This paper mainly expounds the principle and the realization process

of the design on attitude control system for the car falling into the water and demonstrates the feasibility of the system. There is still room for further improvement in this paper. The design on attitude control system for the car falling into the water has opened up a new direction in the field of passive safety and make our car more secure and reliable.

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