Study of Active and Passive Safety Systems and Rearview Mirror Impact Test

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ABSTRACT : *The terms "Active" and "Passive" are simple but significant and important terms in the world of automotive safety. "Active safety" is used to refer to technology assisting in the prevention of a crash and "passive safety" to components of the vehicle (primarily airbags, seatbelts and the physical structure of the vehicle) that help to protect occupants during a crash. We have focused on every aspect of a particular safety system. In this paper we have discussed working principle, sensors used in brief. Rear view mirror is an important safety device. Rear view mirrors on road vehicles are primarily a protective safety device providing clear view towards the rear of vehicle.In this paper we have studied mirror impact testing of automotive rearview mirrors according to AIS: 001(Part 1) (Rev.1)2011 which is performed to simulate the crash of a human head hitting the mirror.*

***Keywords** –Active Safety, Passive Safety, Mirror impact test, AIS: 001*

I. INTRODUCTION

Automobiles are much more dangerous to pedestrians than they are to drivers and passengers. Two-thirds of 1.3 million yearly auto related deaths are pedestrians. Since at least the early 1970s, attention has also been given to vehicle design regarding the safety of pedestrians in car-pedestrian collisions. The normal approach of active and passive safety systems deliver their functionalities only at their phase specifically. Active safety features can help prevent crashes [1, 2]. Passive safety features prevent the occupants from injury after an accident occurs. Active and Passive Safety Systems are very important as per the Automotive Industry Standards (AIS) [9]. One of the major active automobile safety devices is a rear view mirror and the testing of rear view mirrors is a significant part as per AIS. The test described simulates an object striking the mirror at a velocity of 3.1 ms^{-1}, compared to a velocity of 13.4 ms^{-1} when the mirror of a car travelling at 30 miles per hour hits a stationary object. This velocity would be considerably higher if the car mirror clipped an oncoming car. These cases highlight that there is a continuing risk of severe eye injury following an impact on the back surface of an external rear view mirror. The test is based on the effect of a low velocity impact.

II. SENSORS

2.1 Ultrasonic Sensors

Ultrasound can be used in detection and ranging applications using the time of flight principle to estimate the distance to an object. Ultrasonic emissions are effectively sounds waves with frequencies higher than that audible to the human ear, suitable for short to medium range applications at low speed. A scanning sonar sensor based on a phased array of ultrasonic sensors facilitates gathering information on the distance, angular position, velocity and nature of surrounding obstacles. Ultrasonic sensors provide a good indication of vehicle to obstacle distances, are less susceptible to being affected by a build-up of debris, have good response times and are low cost. However their performance is only suitable for short and medium range applications, fluctuations in operating voltage reduces performance and the accuracy of object detection is sometimes affected by reflected signals.

2.2 Yaw Rate Sensor

Working Principle:

The drive portion looks and acts exactly like a simple tuning fork. Because the drive tines are constructed of crystalline quartz, it is possible to electronically “ring” this tuning fork. Each fork tine has a mass and an instantaneous radial velocity which changes sinusoid ally as the tine moves back and forth. As long as the fork’s base is stationary the momenta of the two tines exactly cancel one another and there is no energy transfer from the tines to the base. In fact, it takes only ~6μW of power to keep the fork ringing. As soon as the tuning fork is rotated around its axis of symmetry, however, the Coriolis principle exerts a profound influence on the behaviour of this mechanism. By convention, (the "right-hand rule"), the rotational vector, ω_i is described by an arrow that is aligned with the axis of rotation. The instantaneous radial velocity of each of the tines will, through the Coriolis effect, generate a vector cross product with this rotation vector.

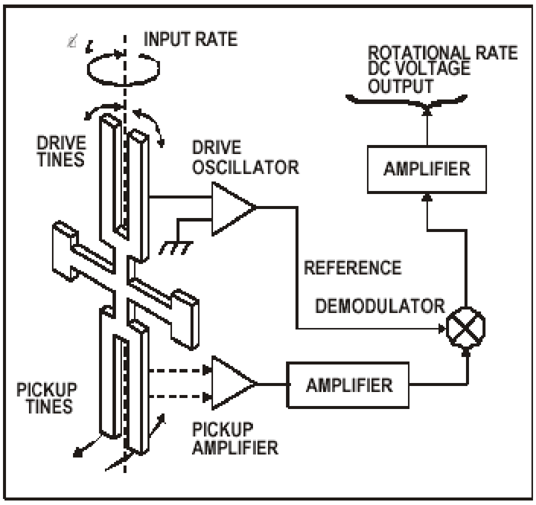

Figure 2.2.1 YAW Rate Sensor architecture

2.3 Steering Torque Sensor

The torque sensor measures the torque applied by the driver at the steering wheel. Based on this, the control unit calculates the steering assistance for the motor. The torque sensor sits on the steering pinion (5). A pole wheel (9) is fitted on the input shaft (2) which is connected to the steering pinion by means of the torsion bar (1). The measuring range covered by the sensor is between +/- 8 and +/- 10 Nm. If the steering torque is higher, a mechanical angle limiter prevents overload of the torsion bar. When the driver applies a torque on the steering wheel, the torsion bar is rotated as is the magnet relative to the sensor. The sensor consists of magneto-resistive elements which change their resistance when the field direction changes. In the process, the voltage follows a sine and cosine curve when the magnet is rotated. The direct rotation angle of the torsion bar is then calculated by means of an inverse tangent function.

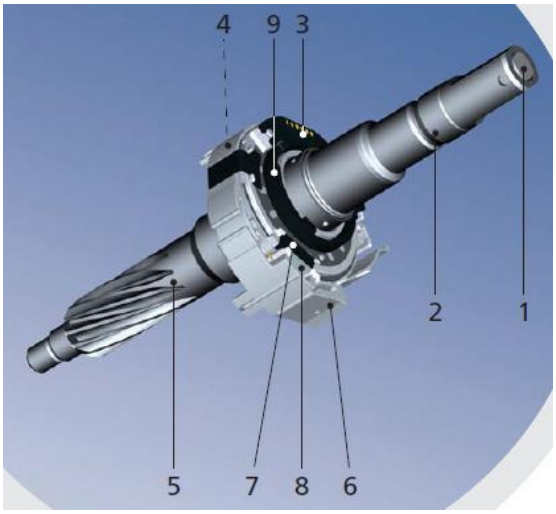

Figure 2.3.1 Sensor placement in steering column

1-Torsion bar, 2-Input shaft, 3-Sensor module, 4-Clock spring, 5-Steering pinion, 6-Plug, 7-Index magnet (optional), 8-Index sensor (optional), 9-Pole wheel

The high safety demands on electric steering systems require detection of all faults occurring on the sensor and creation of a safe condition of the steering system. The sensor data are transmitted to the electronic control unit via a very rugged digital interface. Optionally, the torque sensor can also accommodate an index magnet (7) and an index sensor (8). The index sensor delivers a signal to the ECU for each full steering wheel turn. In combination with the data from the rotor position sensor and the wheel speeds, the electronic control unit is able to calculate the steering angle with a resolution < 0.05°.

2.4 Wheel Speed Sensor

Within this sensor there are two different principles used. The two principles used are active and passive speed sensors. According to Bosch the active sensor are becoming more and more widespread. The active sensors use a magnetic field for the contact less detection of the wheel speed and they are capable of recognizing the direction of rotation as well as a standstill.

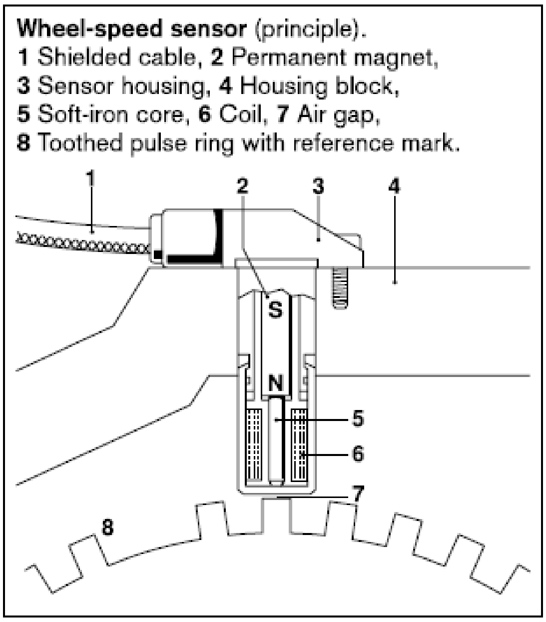

Figure 2.4.1 Wheel Speed Sensor Construction

The soft-iron core of the sensor is surrounded by a winding, and located directly opposite a rotating toothed pulse ring with only a narrow air gap separating the two. The soft-iron core is connected to a permanent magnet, the magnetic field of which extends into the ferromagnetic pulse ring and is influenced by it. A tooth located directly opposite the sensor concentrates the magnetic flux in the coil, whereas the magnetic flux is attenuated by a tooth space. These two conditions constantly follow on from one another due to the pulse ring rotating with the wheel. Changes in magnetic flux are generated at the transitions between the tooth space and tooth (leading tooth edge) and at the transitions between the tooth space (trailing tooth edge). In line with Faraday's law, these changes in magnetic flux induce an AC voltage in the coil, the frequency of which is suitable for determining the rotational speed.

III. ACTIVE SAFETY SYSTEMS

3.1 Electronic Brake Force Distribution (EBFD)

Electronic brake force distribution (EBD or EBFD), Electronic brake force limitation (EBL) is an automobile brake technology that automatically varies the amount of force applied to each of a vehicle's brakes, based on road conditions, speed, loading, etc. Always coupled with Anti-lock braking systems, EBD can apply more or less braking pressure to each wheel in order to maximize stopping power. Mostly, the front end carries the most weight and EBD distributes less braking pressure to the rear brakes so the rear brakes do not lock up and cause a skid. The wheel speeds on the front and rear axle are compared. If the difference exceeds a maximum value, over braking is detected on the rear axle and the EBD system intervenes. The EBD system then closes the ABS inlet valves for the left and/or right rear wheel, thereby preventing further pressure build-up and maintaining the pressure in the wheel brake cylinder. In some systems, EBD distributes more braking pressure at the rear brakes during initial brake application before the effects of weight transfer become apparent.

3.2 Electronic Stability Control (ESC)

Electronic Stability Control (ESC), also referred to as Electronic Stability Program (ESP) or dynamic stability control (DSC), is a computerized technology that improves the safety of a vehicle's stability by detecting and reducing loss of traction (skidding) [5].When ESC detects loss of steering control, it automatically applies the brakes to help "steer" the vehicle where the driver intends to go. Braking is automatically applied to wheels individually, such as the outer front wheel to counter oversteer or the inner rear wheel to counter understeer. Some ESC systems also reduce engine power until control is regained. ESC does not improve a vehicle's cornering performance; instead, it helps to minimize the loss of control. There are five main components to an ESP system:

1. Wheel speed sensors
2. ESP-Hydraulic unit with integrated ECU
3. Steering angle sensor
4. Yaw rate sensor
5. Engine-management ECU for communication

1. Speed Sensors:

The ESC system needs some way of knowing when a wheel is about to lock up. The speed sensors, which are located at each wheel, or in some cases in the differential, provide this information.

2. Hydraulic modulator with attached ECU:

The hydraulic modulator places the ECU's command into use and control the pressure of the individual wheel brake cylinders by using the solenoid valves. The hydraulic modulator is located within the engine compartment between the brake master cylinder and the wheel brake cylinders. By placing the modulator here it keeps the hydraulic lines can be keep short. The modulator has input and output solenoid valves to control the pressure in the individual wheel brakes. ECU takes all electrical and electronic tasks as well as the control task of the vehicles systems.

3. Steering Angle Sensors:

The complete task of the steering angle sensor is to measure the position of the steering by determining the angle. The driving steering angle sensors finds out the position the driver would like to be in and from there calculates where the driver should be with the vehicles speed and desired braking pressure.

4. Yaw-Rate and Lateral Acceleration Sensor:

A yaw sensor records all the yawing movements of the vehicle around its vertical axis. Also by using the information from an integrated lateral-acceleration sensor, the status of the vehicle can be determined and compared to the driver‘s wishes.

5. Communication with Engine Management:

The data bus enables the ESC control unit to communicate with the engine control unit. In this way, the engine torque can be reduced if the driver accelerates too hard in a certain driving situation. The compartment also allows ESC to compensate for any excessive slipping provoked by the engine drag torque.

3.3 Autonomous Emergency Braking System

An Advanced Emergency Braking System (AEBS) or Autonomous Emergency Braking (AEB) is an autonomous road vehicle safety system. AEB systems automatically apply the brakes to reduce speed when sensors on the vehicle identify a likely collision and the driver has not applied sufficient braking and is not attempting to steer away. It uses sensors to monitor the proximity of vehicles in front and detects situations where the relative speed and distance between the host and target vehicles suggest that a collision is imminent. It employs state of the art radar technology specifically designed for Automotive Radars or car radars and its primary function is to avoid collisions or mitigate the impact during critical situations by applying the brakes automatically.

The AEB system is designed to function on different sets of road scenarios. First, it alerts the driver of existing obstacles in front of a car. If the driver fails to act on time to avoid a collision, the AEB system will automatically apply emergency brakes with different levels of force using its intelligent algorithm for speed, trajectory, momentum, and other factors to avoid or at least lessen the impact of the collision. Some models will deploy or activate the restraint system ready for impact.

IV. PASSIVE SAFETY SYSTEMS

4.1 Supplemental Restraint System (SRS)

The supplemental restraint system is designed to restrain a body in the event of a sudden deceleration. The supplemental restraint system is designed to work without any actions from the driver or passengers except putting on the seatbelt. The reason why the AIRBAGS are called "supplemental" restraints is because the SEATBELTS are the first line of defence in a collision. For the airbags to work effectively, seatbelts should be worn at all times. The seatbelts keep the body restrained in the seat, so that the only body movement is bending from the hips. However, seatbelts do stretch. Sometimes they stretch to a point where the driver's head could strike the steering wheel. The hands holding the steering wheel should be in the "10 & 2 o'clock" position, instead of the "11 & 1 o'clock position.

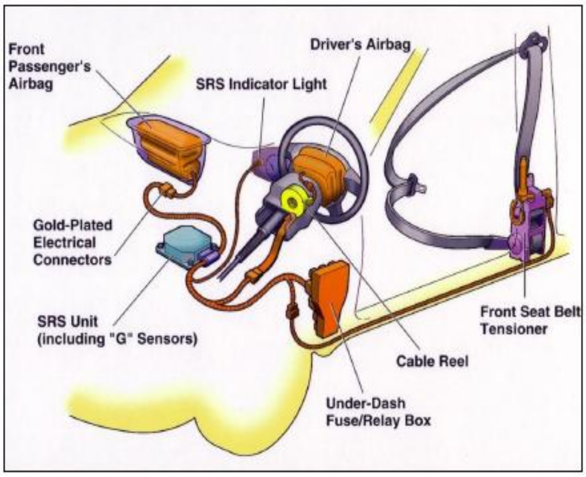

Figure 4.1.1 Components of SRS

4.2 Emergency- Call System (E-Call)

E-Call is a combination of an In Vehicle System (IVS) and a corresponding infrastructure of Public Safety Answering Points (PSAPs) that use Information and Communications Technologies .The IVS automatically calls the PSAPs and transmits location data from the scene of road accidents. Thus, the response time of the emergency services is cut drastically, saving lives and resulting in less severe injuries. E-call system features:

1. Communicate crash information to PSAP when crash is sensed in network.
2. Communicate crash information to PSAP when E-Call is manually triggered.
3. Add location and severity of crash in the MSD.
4. Interface with vehicle infotainment.

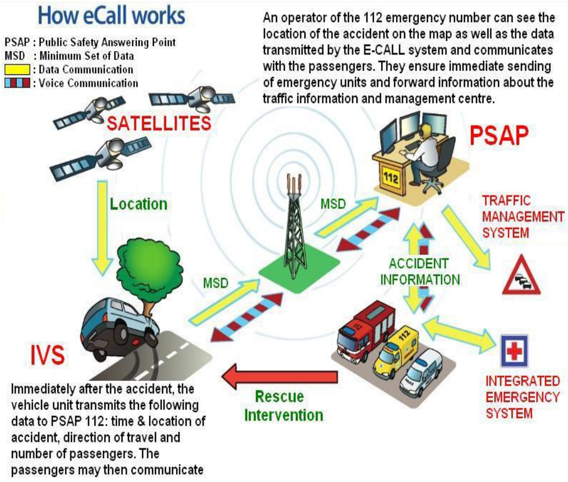

Figure 4.2.1 Overall architecture of E-Call System

V. MIRROR IMPACT TEST

Mirror Impact Test is one of the tests to be performed on Automotive Inner Rear View Mirrors (IRVMs) and Outer Rear View Mirrors (ORVMs) to certify them according to AIS-001(Part 1) (Rev.1): 2011,ECE R46 Rev 3 for safety purposes [9]. Basic principle of the “Mirror Impact Test” is to find out angle turned by mirror, after the impact made by a pendulum from mirror’s original position. This method includes testing of rear view mirrors, which are mounted on a platform and struck by a pendulum of total mass 6.8 kg at the centre of mirror. The angle through which the mirror deviates is measured on protractor mechanism. As per criteria of angle in standards, company test agency certifies a mirror.

5.1 Why Mirror Impact Test?

1. Glass entering the car through an open side window from a broken external rear view mirror is an uncommon but potentially preventable cause of severe ocular injury.
2. The risk of injury to bike riders and pedestrians after contact with the outside mirrors is considerably reduced by the mirror folding mechanisms.
3. These mirrors designed for use in cars/bikes/heavy vehicles have to undergo a “pendulum test” using a 6.8 kg weight on a pendulum of 1 metre length released at a 60 degree angle from the vertical to represent the impact of a head hitting the mirror.
4. ARAI tests these folding mechanisms with pendulum impact tests.

5.2 Test Rig Description

The test rig consists of a pendulum capable of swinging about two horizontal axes at right angles to each other. The end of the pendulum comprises a hammer formed by a rigid sphere of 6.8 kg weight with a diameter of 165 ± 1 mm having a 5 mm thick rubber covering of Shore A hardness 50. A device is provided which permits determination of the maximum angle assumed by the arm in the plane of release.

Figure 5.2.2 – Impact Test Rig

5.3 Results of tests according to AIS: 001 Standard.

1. The pendulum shall continue to swing after impact in such a way that the projection of the position assumed by the arm on the plane of release makes an angle of at least 20° with the vertical. The accuracy of measurement of the angle shall be within ± 1°.This requirement is not applicable to mirrors stuck to the windscreen.
2. The required angle to the vertical is reduced from 20° to 10° for Class II and Class IV rear-view mirrors and for Class III rear-view mirrors

which are attached to the same mounting as Class IV mirrors.

3. Should the mounting of the mirror break during the tests described for mirrors stuck to the windscreen, the part remaining shall not project beyond the base by more than 10 mm.
4. The reflecting surface shall not break during the tests described.

VI.CONCLUSION

We have studied the various active and passive safety systems in detail. This paper can help further in developing new controller systems by providing basic information or working of the systems discussed. The basic principles behind the technologies and sensors used in these systems have been studied. Also we have studied the importance and procedure for mirror impact testing of automotive rearview mirrors.

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