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THE NEW GENERATION OF THE BMW CHILD SEAT AND OCCUPANT DETECTION SYSTEM SBE 2

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ABSTRACT–A new generation of the BMW child seat and occupant detection system SBE2 for a smart airbag system is described. The SBE2 system consists of two subsystems: OC (Occupant Classification) and FDS (Field Detection System). The OC system is a force sensitive sensor array that measures a pressure profile. The FDS system detects child seat and occupant according to the change of electrical field generated by four capacitive plates. Combining the signals from both subsystems, the BMW SBE2 system can distinguish fully automatically between a child seat and a person.

KEY WORDS : Child seat, Occupant detection

1. INTRODUCTION

The number of cars being equipped with an airbag system is increasing. The violent deployment of the airbag can cause danger to children placed in rear facing child seat and to small women sitting close to the fascia. Therefore the airbag should be suppressed in such cases.

Currently there were launched some solutions for switching off the airbag. These are switch-, transponder-, ultrasonic-, infrared- and capacitive system. However, They proved not to be robust and reliable enough:

Switch:	switch can be set on incorrect position by person
Transponder:	requests a special purpose bought child seat
Infrared:	interference is possible and difficult to eliminate
Capacitive:	fails when metallic objects are placed on the seat
Ultrasonic:	temperature influence

The new generation of the BMW child seat and occupant detection system SBE2 has been developed. It is based on two different physical principles:

1. Pressure profile measured by a force sensitive sensor array;
2. Change of electrical field recorded in capacitance.

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The SBE2 electronics combines the signals from both subsystems and classifies the current passenger seat status, which is sent to the airbag control unit. The following features characterize the BMW SBE2 system:

- Fully automatic detection of universal child seats
- No requirement for a dedicated seat or for additional actions of the driver
- Reliable suppression of deployment of the passenger airbag when necessary
- Achievement of optimum reliability and safety using a combination of two different physical principles of measurement
- Invisible integration of both systems into the seat

2. SYSTEM DESCRIPTION

As mentioned above, the BMW SBE2 system consists of two subsystems: OC system (Occupant Classification) and FDS system (Field Detection System). Both subsystems are described in detail below.

2.1. OC System

The OC system can be briefly summarized as following:

The human buttocks imprint a typical profile on a car seat cushion. This pressure profile is measured by a force-sensitive resistor sensor array integrated into the seat within a plastic laminate. OC electronics classifies the pressure profile into one of several classes based on preprogrammed profile characteristics (Figure 1).

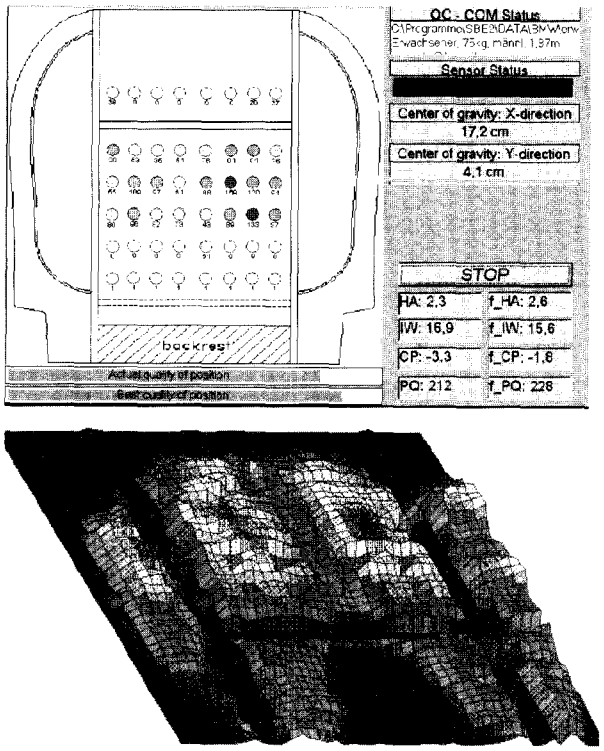

Figure 1. OC sensor array and pressure profile.

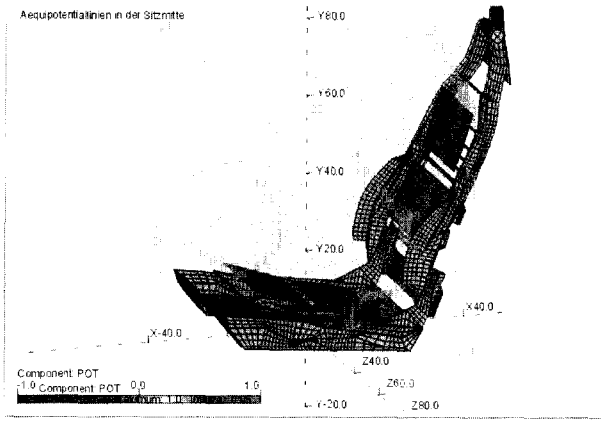

Figure 2. Electrical field distribution.

2.2. FDS System

The FDS system has been developed at BMW Group and is based on the capacitive principle.

2.2.1. FDS configuration

The FDS configuration allows a very great difference of the measured capacitance values between person and child seats.

2.2.2. FDS technology

There are some technical obstacles for capacitive systems in automotive applications. Some features of the BMW FDS system solution are described as following:

The DSP technology, a complex filter and a frequency scan mode are used to suppress EMC problems (electromagnetic compatibility).

The humidity problem is eliminated by acquisition of complex conductance by using two different measurement modes. The complex electrode conductance and the conductance between the electrode and guard are measured to determine the humidity. The humidity mainly causes a phase change in both kinds of conductance.

Suitable electrode and guard material characterized by permeable conducting fabric, robust against corrosion and aging is used to fulfill requirements for functionality and comfort. The electrode and guard, for example, have to be permeable because of the seat heating.

Highly flexible, crimp-connectable shielded cable is chosen because of comfort, manufacturing process and service.

2.2.3. FDS verification

The FDS system was checked for physiological aspects of capacitive sensing. The important data are summarized as following:

An ultrasonic-frequency in the range from 40 to 120 kHz is used in the FDS system. Nerve stimulation effects which maximum is at 10-100 Hz are avoided.

The FDS output power is smaller than 0.2 $\mu W/cm^2$ (sunlight: 100 mW/cm^2, cellular phone: 1-15 W). This ultra low power causes no tissue heating.

Because the FDS system has no magnetic component, there is no penetration of body. Following is a comparison of the magnetic flux density of several electrical devices:

Hair dryers and electrical shavers:	up to 0.07 mT
Transponder systems:	about 0.004 mT
Capacitive sensor:	0.04 μT

In the FDS system the output power is automatically decreased down to 25% of its maximum when a person occupies the seat.

2.3. SBE2 Algorithm

Figure 3 shows the SBE2 algorithm. In the FDS algorithm the static classification is firstly calculated according to the four measured capacitances and then the dynamic classification gives the final FDS classification.

The SBE2 algorithm combines the classifications of both FDS and OC subsystem and determines the final

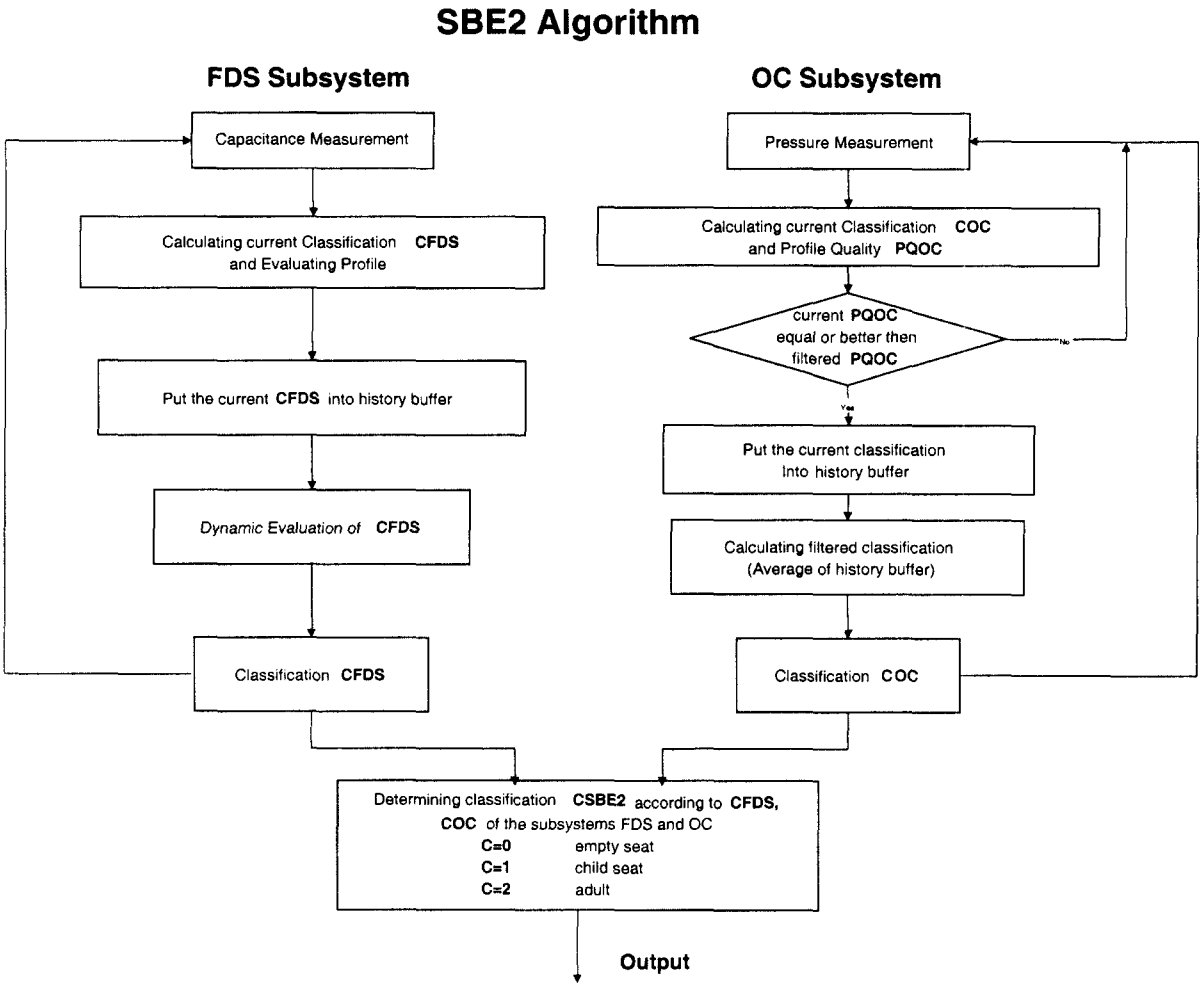

Figure 3. SBE2 algorithm.

SBE2 classification. The SBE2 classification can have three different values that are relevant for the airbag control unit:

Class = 0	empty seat
Class = 1	child seat
Class = 2	adult

The deployment of the airbag in case of a crash is enabled due to the SBE2 classification.

2.4. SBE2 Electronics Technology

The BMW SBE2 electronics shown in Figure 4 consists of a power supply, an analogue section, DSP and a microcontroller.

The DSP (Motorola 56362) and the microcontroller (Motorola 68C12D60) work together whereby the microcontroller works as the master and the DSP as the slave. The microcontroller starts up and initializes the DSP that then generates a sine wave signal for the capacitive plates. The DSP measures the current from the amplifier and filters it through a digital filter. The filtered current value is used to adjust the amplitude of the sine wave (produced by the DSP) to a set value. The values of the current and voltage then are applied in the microcontroller to calculate the capacitance, phase, sideband and additional values of the four electrodes.

The capacitance value is used for determination of the seat occupation. Electromagnetic disturbance is indicated by the sideband values. The phase value shows the humidity status and is also important in the error handling. The DSP sends these data to the microcontroller before the next measurement is initiated. In the FDS algorithm the microcontroller applies the data to determine the FDS classification levels. The current operating frequency for the FDS system is dynamically evaluated by an empty field measurement. If the operating frequency changes, the DSP proceeds to perform a complete measurement cycle.

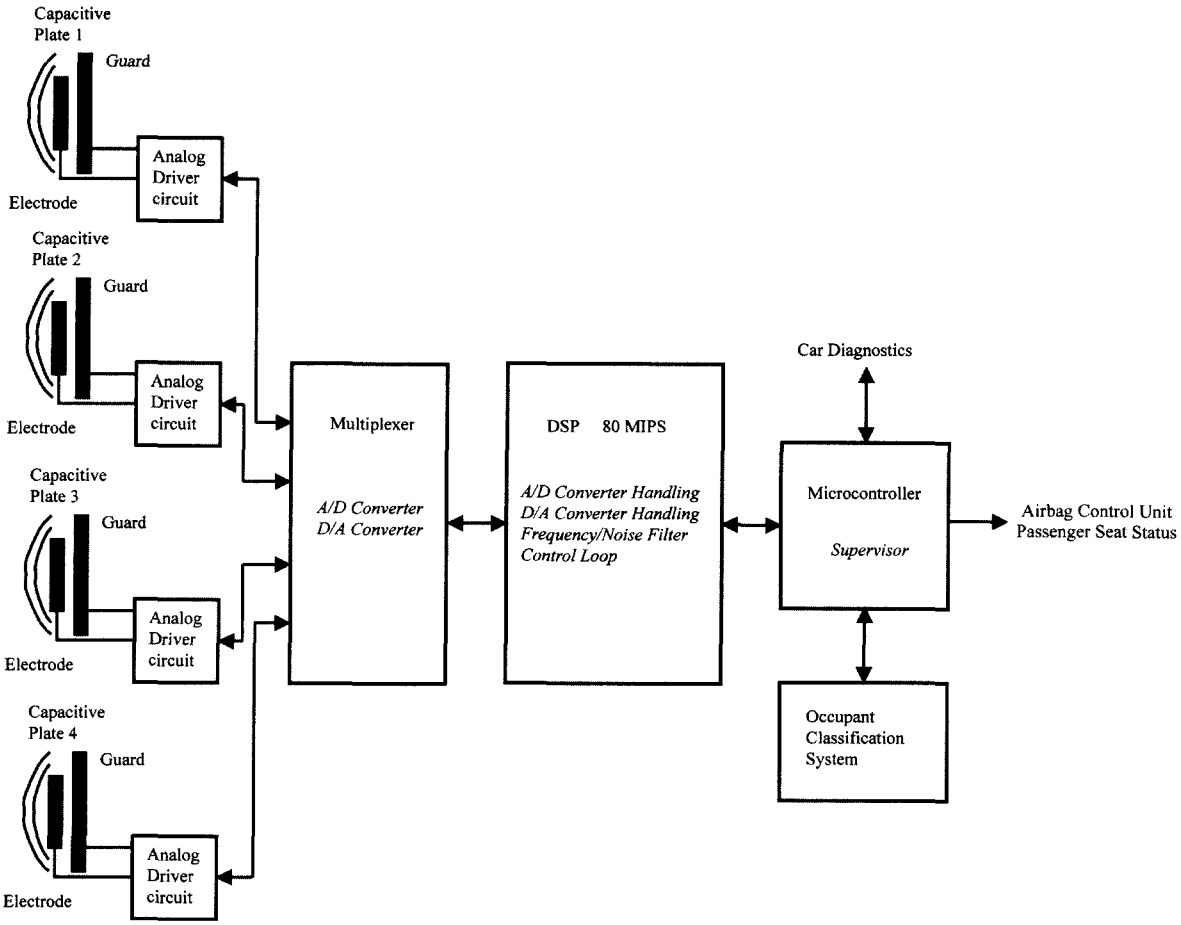

Figure 4. SBE2 electronics.

The SBE2 electronics also handles the communication with the OC system. It receives the classification data from the OC electronics periodically.

The final result classification is accomplished by the SBE2 electronics combining the FDS classification value with the OC classification value. It is sent to the airbag control unit.

All diagnostics including the detection of failures, the storage and erasure of data and the communication to the diagnostic bus are carried out by the microcontroller.

3. CONCLUSION

A new generation of the BMW child seat and occupant detection system SBE2 has been developed. The SBE2 system consists of the subsystem FDS, based on the capacitive principle, and the pressure subsystem OC. Applying the SBE2 system a more reliable detection of the passenger seat status can be achieved.

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