ELECTRONIC REGULATION OF AN AUTOMATED CAR TYRES PRESSURE CONTROL SYSTEM

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Abstract: Modern cars have a lot of features and electronic systems which support the driver in dangerous driving situations. Such systems are not only developed for keeping the cars under control, but they also try to improve the subjective feeling during driving and comfort. One of such systems has the task to measure and control the pressure of the tyres: Automated Tyres Pressure System (ATPS). The prototype system which is mentioned in this paper is able to check the pressure of the tyres and to adapt automatically the pressure of each tyre to the currently existing driving situation. The main principles concerning hardware structure, the particular software architecture and also some results, which have become important during the development of a first prototype car, are mentioned and described.

Keywords: Control applications, System engineering, Automotive, Pressure measurements, Tyres, Dynamic behaviour, Valves, Prototyping, Prediction methods, Sensors.

1. INTRODUCTION

Nowadays the automotive industry is one of the most exciting and challenging fields of development, where the electronic engineering takes place. A key role in the modern development of a vehicle is played by the design of electronic hardware and software. Also economical cars have mounted a lot of decentralized electronic control units, which have the task to keep factors like security, consumption, emission, performance and comfort under control. In this field it is very important to mention the electronic control of the driveline, vehicle dynamics e.g. global chassis controller, traction control, the antilock braking system, the steer by wire system and fault detection device, see (Bosch, 2000) and (Loomann, 2003).
A revolutionary investment in safety and comfort, as well as vehicle stability, is the dynamic control of the tyres pressure during driving. Statistics show that every second technical reason for a car accident is due to the tyres: in fact a too low tyres pressure cause more rolling friction, the tyres become more noisy and the rubber get warm, see (Biermann, 2004). Even the best test driver has problem to control a car with a broken tyre. The automatic adaptation of the tyres pressure, depending on the currently existing driving situation, changes the whole vehicle dynamics and makes the car more reliable, e.g. if the tyres are damaged or have small leakages. In the next few years, the cars which have to be sold in the United States have to be equipped with systems which indicate a low tyres pressure, see (Normann N., 2000). Providing the driver an accurate infor-

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mation about the pressure levels, it could create better security feeling. Most systems, which are state of the art, detect such a critical situation by the changing in the frequency spectrum of the rotating tyres, or they measure directly the pressure of each tyre, see (Bochmann H., 2005). In connection with this fact, it seems a logical further step, not only to indicate the driver that the pressure in one tyre is not correct, but also to control it. A revolutionary investigation is the electronic-pneumatic regulation of the pressure of the tyres (ATPS). Existing tyres pressure measurement systems use pressure sensors, with battery inside, which are mounted on the valves of the wheels. By introducing a measurement cycle and a transmitting cycle the information of the currently measured pressure can be transmitted to a control unit, see (Technical, 2003). In special situations these concepts might cause problems because of lacks in the energy supplied by the battery inside the wheels, or because of issues in the transmission phase. Other systems use the changing in the radio frequency spectrum in combination with piezo-electric sensors for operating without batteries. These systems have the disadvantage that they can't operate all the time. Therefore a prototype car has been equipped with a system which is independent of such tyres sensors, and has already the possibility to adapt the tyres pressure to the currently existing driving conditions. Especially in situations where the tyres have small leakages, the so called ATPS has the advantage that the driver is warned that the tyres loose air, but he has the possibility to drive to the next service station, see (Ringdorfer M., 2005). The main principle of the system, which is described in this paper, is to measure the pressure of the tyres with standard pressure sensors located in the ATPS on the car, and to adapt the tyres pressure if necessary. This includes the decreasing of the pressure if it is too high, by releasing air through the tyres rim, and it also includes the refilling of the tyres, if there are small leakages.

2. HARDWARE AND SOFTWARE CONFIGURATION

2.1 Electro-Pneumatic System Description

As shown in Fig. 1, the hardware system consists of a rapid control prototype unit (MABX), a Power- and Communication-Interface (PCI) and an air-pneumatic unit, called Central Air Unit (CAU). In Fig. 3, it is possible to see a more detailed schematic of the air-pneumatic unit. All the valves in the CAU, are actuated by the rapid control prototype unit. These parts are installed in the boot bottom in a prototype car, in the space normally assigned to the reserve wheel (not anymore necessary). Each tyre is connected to the

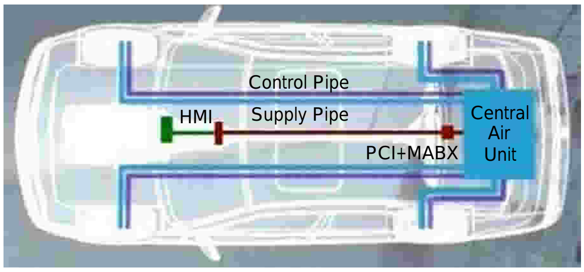

Fig. 1. Automated tyres pressure control system mounted in a prototype car.

air unit by using two pneumatic pipes: one Control Pipe for actuating the valves in the tyres rim ($V_9, \ldots V_{12}$), the other Supply Pipe for delivering the air to the tyres. The pneumatic connections between pipes and rims in the tyres are describe in the (*SSF* GmbH Patent, 2003). The driver can instruct and supervise the ATPS via a Human Machine Interface (HMI) mounted in the cockpit, see Fig. 2. From the electrical point of view, the PCI

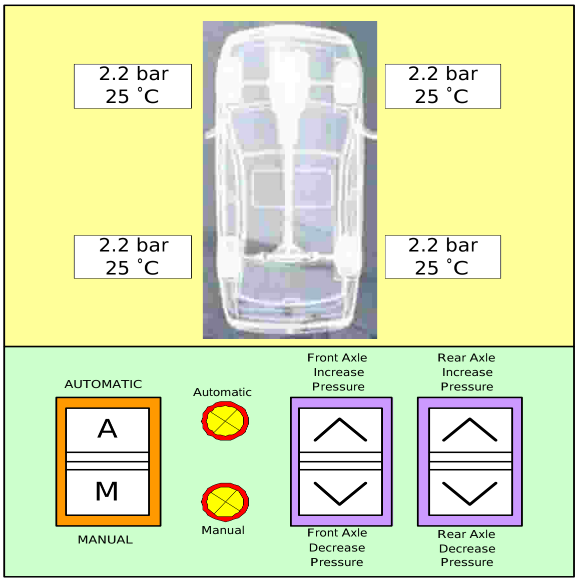

Fig. 2. Human Machine Interface mounted in the prototype 'Air Vehicle'.

provides the rapid control prototype unit information from the vehicle CAN and from an installed HMI. With this information and the status data coming from the CAU, the software algorithm calculates the necessary actuation sequences for controlling the tyres pressure. The Control Commands are send to the power interface of the rapid control prototype unit and forwarded to the air unit. The air unit, shown in Fig. 3, consists of: pressure sensors S_1, S_2 and S_3, for measuring the pressure in the accumulator P_{S1}, and for measuring the pressures in the supply pipes P_{S2} and P_{S3}, valves for setting up the necessary tyres pressure levels $V_1, \ldots V_{12}$, a compressor C_1, composed of a motor M_1 and a pump P_1 and an accumulator A_1 for storing the compressed air. Additionally an air-dryer AD_1 is present, which is used for