Fabrication of Auto-Braking System for Pre-Crash Safety Using Sensor

Eung Soo Kim
Div. Digital Media Engineering, Pusan University of Foreign Studies, Busan, Korea
e-mail: eskim@pufs.ac.kr

Abstract

The auto-braking system was designed by VHDL and fabricated to keep a distance between two cars. It provides pre-crash safety system for intelligent car. This module can detect the distance between front vehicle and driver's vehicle to keep a constant distance using a sensor and operate the brake system forcibly if the driver does not decrease the speed of car. The system displays the distance between the two vehicles and the speed of your vehicle. The performance of the system was good.

Keywords: *Auto-Braking System, Pre-cash safety, Sensor*

1. Introduction

An automobile has been used to move human beings or something since the automobile was invented and the automobile technology has been developed within the last few years. Recently, the automobile is thought as daily necessaries because we spend much time in an automobile and enjoyed the entertainment such as game, e-mail, DVD, mp3, and internet etc. in the car. In nowadays, the intelligent car with adaptive cruise control, lane keeping technology, auto-parking system, tire pressure monitoring system (TPMS), and prevent pre-crashing system has been equipped because we need the convenient and intelligent car [1-3]. These new automobile technologies are made possible by the development of semiconductor technology, optical technology and software technology.

The use of electronic components in automobiles is set to accelerate and with ongoing efforts to improve safety and comfort. 250 electronic components are used in a car, for example, 50 MCUs are used in a car. Therefore, car makers in Europe and Japan are developing for safety such as both collision safety and preventive safety and new car technology for intelligent car such as intelligent transport system (ITS), rear view camera system, Road-to-vehicle and Inter-vehicle Communication Systems, auto-parking system, hybrid car, electric car, and hydrogen fueled car [4]. In addition, some vehicle networks will enter commercial use, such as the FlexRay interface instead of CAN bus for onboard local area network (LAN), which supports high-speed transfer, and MOST (media oriented systems transport) or IDB-1394, which can move multimedia data, that is audio and video signals, from multiple camera systems or multimedia devices, such as DVD, navigation system, mp 3, TV tuner, and CD changer etc. at once. Car makers are beginning to develop equipment for high-end vehicles with systems to sense roadway conditions using cameras, radar, sensors and such in an effort to avoid accidents. The traffic accident is increasing as automobile production has been increasing. It is important to prevent accidents and to protect the driver and pedestrian when accidents were occurred. Therefore, pre-crashing system will be demanded. The pre-crash system is to prevent front-end, rear-end, right-turn and left-turn accidents on roads with poor visibility by using sensor network to find invisible vehicles, which are to be detected by autonomous on-vehicle sensors. The pre-crashing system is processing the sensor data and controlling the vehicle to prevent front-end, rear-end accidents and accidents caused by careless driving. The development of such systems to automatically control vehicles and avoid accidents will accelerate in the future.

In this paper, we designed the auto-braking system which keeps a distance between the front car and driver car to prevent accident using sensor and fabricated it using FPGA and VHDL [5]. The power consumption of system was very small and another sensor or camera will be added easily. The performance of the system was good.

2. Design and Implementation

The fabricated auto-braking system has the sensor part and signal processing part to prevent an accident as shown in Figure 1. It performed monitoring the environment and sensor signal processing. The sensor embedded in vehicle will detect the road environment, such as self-velocity, distance from front vehicle, and surroundings vehicles, using infrared sensor and ultrasonic sensor. These sensors were operated all the time during driving. The processing part accepted the signal from sensors and processed the signals and generated the instructions and transferred the generated instruction to control unit of transmission and brake of vehicle. There are three cases occurred in real situations. One case is that the distance between the front car and driver's car is far enough to defend crashing and self-velocity is the same velocity of front car or slower than that of front car. In this case, the driver's car is continuously running without changing its velocity. Another case is that the distance between the front car and driver's car is near and self-velocity is slower than that of front car. In this case, the driver's car is also continuously running without changing its velocity. Another case is that the distance between the front car and driver's car is near and self-velocity is faster than that of front car. In this case, the driver's car is continuously running only when the driver reduce speed. But if the driver does not reduce speed, the auto-braking system may forcibly reduce the speed of driver's car to protect an accident. The reason is that if the driver does not reduce speed, the accident will be occurred and the driver will be hurt.

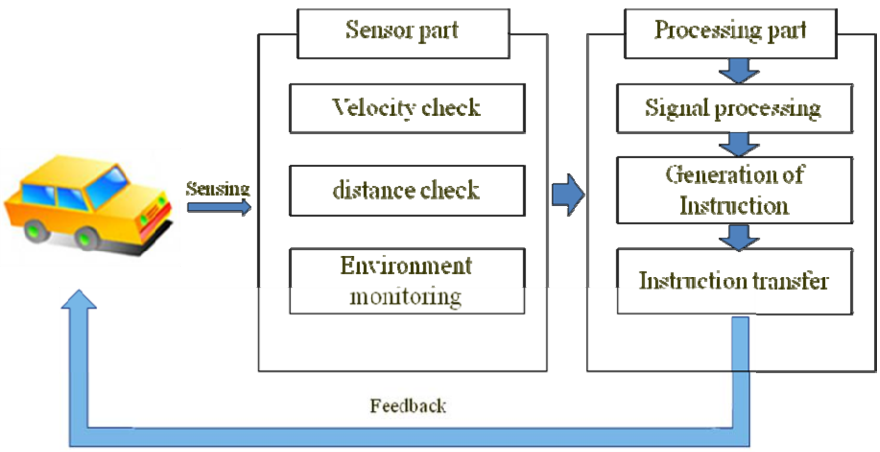
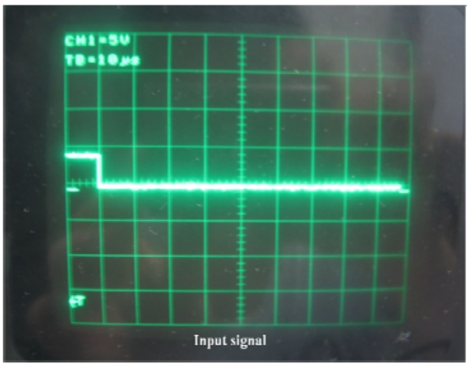


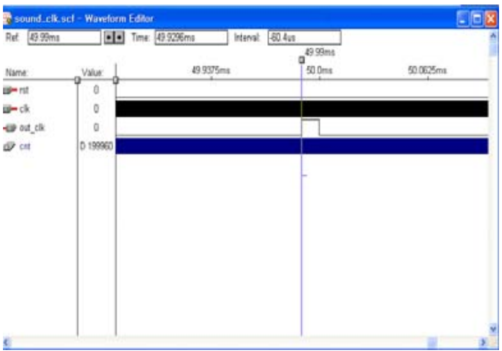
Figure 1. The operation principle of the fabricated auto-braking system.

The important thing in auto-braking system is detect the distance and speed of front vehicle to prevent a traffic accident. We chose an ultrasonic sensor used to detect the distance between a front car and driver's car because we mounted the fabricated system on a miniature car with a reduced scale of 1:20. The detectable range of the ultrasonic sensor was up to 3m.

We have made 4 MHz clock signal to generate ultrasonic sensor signal. The generated sensor signal was PWM (pulse width modulation) signal when 10 µs input signal was given as shown in Figure 2(a). Fig 2 (b) shows the simulation result of sensor input signal to detect the distance. The simulation was carried out by VHDL. The PWM signal which was reflected from the front car was varied from 1 ms to 11 ms according to the distance between the front car and driver's car. Figure 3 (a) shows the simulation result of distance measurement from front car sensor using 4MHz input signal. The input pulse of sensor with duration of 2ms was displayed in Figure 3 (a). Figure 3 (b) output signal with 1ms pulse duration time. Figure 3 (c) shows the sensor output signal with 10ms pulse duration time. The duration of PWM sensor signal was increasing as the distance between the front car and driver's car is increasing. We divided the reflected sensor signal into 10 values in according to the pulse duration of the reflected sensor signal. The motor of miniature car was varied from low speed to high speed according to these 10 different values, which are sensor output signals. The motor control signal is consists of 4bits and the clock signal of the stepping motor was changed as the variation of the sensor signal.

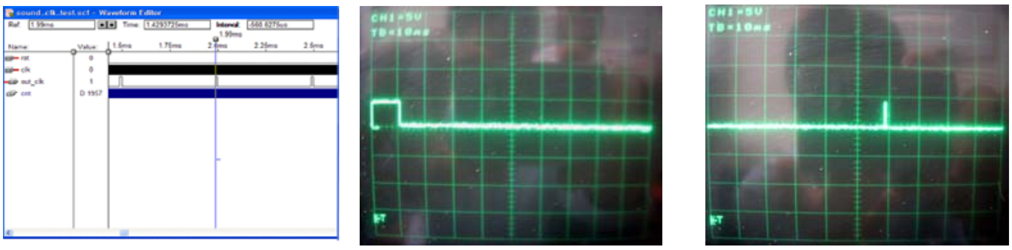
The stepping motor was controlled by the reflected sensor signal, that is, the speed of automobile became slow as the distance became close with the front automobile. If the pulse duration of the reflected sensor signal becomes narrow, it means that our car get near to the front car. So, the driver must decrease the speed of car. If a driver does not reduce the speed of car, the fabricated auto-braking system forcibly makes speed low. The output PWM signal from ultrasonic sensor displayed by 15bits and decided the control signal of motor to





(a) (b)

Figure 2. (a)Sensor input signal with 10 µs in oscilloscope screen and (b) simulation result of input signal.



(a) (b) (c)

Figure 3. (a) the simulation result. PWM sensor output signal with (b) 1ms and (c) 11 ms in oscilloscope screen.

control the speed of motor. Figure 4 shows the source program to detect the motor speed. We used the division by 4000 counters to detect the car speed. Figure 5 shows the simulation result of the program as shown in Figure 4, where the length of arrow means the one rotation of motor. As above mentioned, the motor has 4bits control signal such as 1100, 0110, 0011, and 1001. The stepping motor was controlled by these 4 bits signal. We counted the 1100 signal to measure the speed.

```
process(clk)
begin
  if(clk'event and clk='1')then
   if(cnt1=cnt0)then
     cnt1 <= 0;
     t_clk <= not t_clk;
   else
     cnt1 <=cnt1+1;
   end if;
  end if;
end process;

process(t_clk,direct)
begin
  if(stop='1')then
   step_out<="0000";
  elsif(t_clk'event and t_clk='1')then
    if(direct='0')then
      case buf is
        when "1100"=>buf<="0110";
        when "0110"=>buf<="0011";
        when "0011"=>buf<="1001";
        when "1001"=>buf<="1100";
        when others=>buf<="1100";
end case;
```

Figure 4. The source program to detect the motor speed.

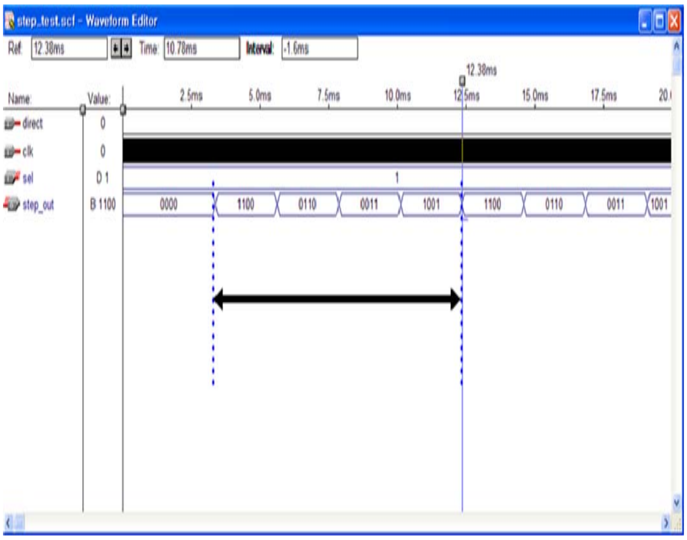
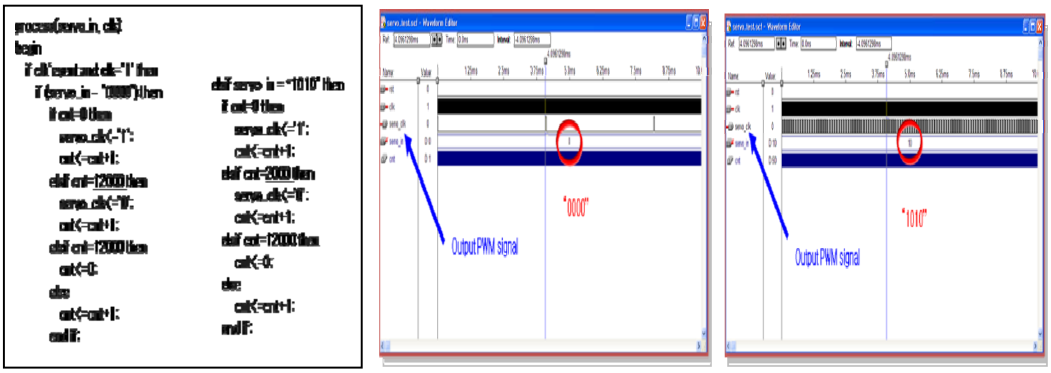


Figure 5. The simulation result of the motor control signal

The auto-braking system moved the brake pedal to reduce the speed if the distance between the front car and driver's car. If the distance between front car and driver's car was far, the pulse duration was the same and the auto-braking system does not work. We use servo motor to move the brake pedal. The brake pedal was controlled by PWM signal, which is different according the distance between the front car and driver's car. The speed of the car was changed according to the angle of the brake pedal. The angle of the brake pedal was varied at the degree of 0, 35, 70, and 90. The speed of the car was decreasing as the angle of the brake pedal was increased. The car was stopped as the angle of brake pedal was 90°. We used servomotor to work the brake pedal. Figure 6 (a) shows the source program to control the brake pedal and simulation result. And Figure 6 (b) shows the simulation result at the PWM signal when the state of steeping motor was 0000, that is stepping motor was stopped. In Figure 6, servo_clk is output PWM signal and Figure 6 (c) shows the simulation result when the state of stepping motor was 1010. We decided the state of stepping motor as arbitrary to simulate the operating of brake pedal. The output PWM signal of brake pedal was varied as the state of steeping motor. The speed of driver's car slowed down as the angle of brake was decreased. Figure 7 shows the block diagram of auto-braking system, where four input signals, clk, rst, direct, and in_clk, were needed in the auto-braking system. The clk input was clock signal, rst input was reset signal stop the operation of ultrasonic sensor, direct input made the stepping motor rotate opposite direction, and the output signal from the ultrasonic sensor was counted by in_clk input signal. The SOUND_CLK part generated sensor signal of the ultrasonic sensor to detect the distance. The sensor signal had 10 μs of pulse duration and the period was 5ms. If the rst signal was inputted, the sensor did not work. The high value of PWM sensor signal was counted at the COUNTBOX part and the count value used 15 bits.



(a) (b) (c)

Figure 6. (a) The source program to control the brake pedal, (b) the simulation result at the PWM signal with 0000, and (c) the simulation result at the PWM signal with 1010.

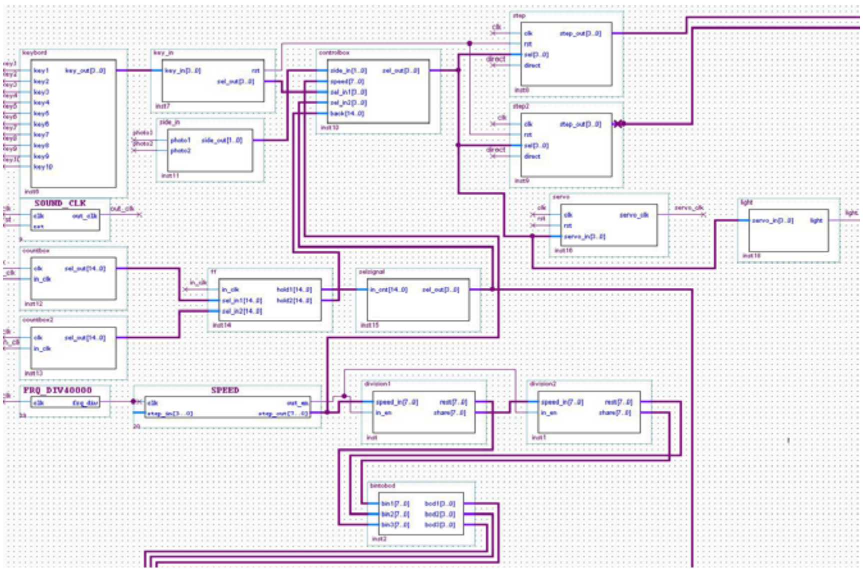


Figure 7. Block diagram of auto-braking system.

The SELSIGNAL part chose the control signal to select the period of the stepping motor clock signal. It selected one of 10 different values of stepping motor speed and the speed of car was varied by the selected signal. The SERVO part generated the control signal which decided the degree of the servomotor according to the select signal. The degree of the servomotor controlled the speed of the stepping motor. We generated 1 KHz signal to calculate the speed by dividing 4 MHz by 4000. It was performed at FQ_DIV4000 part. We have known the speed of stepping motor as counting how many times “1100” appears. This showed the rotation speed of stepping motor. We fabricated the auto-braking system using

FPGA. The distance, the RPM of stepping motor, and the angle of brake pedal was displayed in the LCD panel as shown in Figure 8. In this case, the LCD display showed that the driver's car is running without reducing the speed. The distance can be converted as real distance value. The operation of the system was good.

Figure 8. LCD screen displayed distance, speed, and angle

We also implemented the system using Labview and added surrounding sensing system to prevent an accident. Figure 9 shows the computer monitor which displayed the car speed and the angle of brake pedal by Labview program. It makes easy to implement user interface.

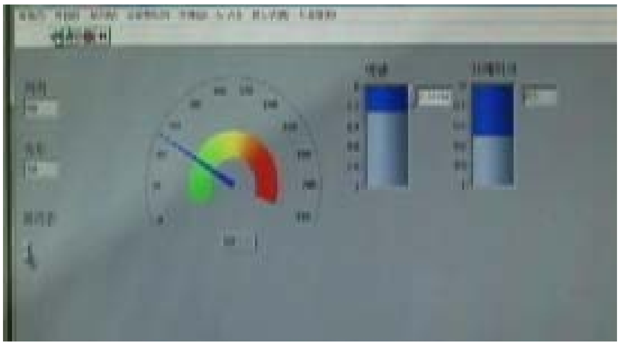


Figure 9. The screen executed by Labview

3. Conclusions

The auto-braking system was designed by VHDL and fabricated using FPGA to prevent accident. The system was mounted on a miniature car and tested. When the distance was getting closer, the auto-braking system was working and the speed will slow down if a driver does not reduce the speed of automobile. We also fabricated the auto-braking system using Labview. We will replace an ultrasonic sensor with a radar sensor as the auto-braking system is mounted on a real automobile.

4. Accknowledgment

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5. References

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