

# Wireless Seatbelt Latch Status Indicator

S. P. Adithya and O. V. Gnana Swathika

**Abstract** Road transportation is an integral part of our daily life. Millions of deaths occur due to road accidents. Thus, safety becomes crucial when it comes to opting for road transport. This paper proposes a wireless seatbelt latch system that is cost-effective and requires a set of electronic components and a sensor which detects the status of the seatbelt and transmits to the Electronic Control Unit (ECU) of the car. The proposed system is tested and validated using Proteus software.

## 1 Introduction

Nowadays, seatbelts in cars are equipped with Hall Effect sensors. If the seatbelt is latched, the Hall Effect sensor experiences magnetic field from a neodymium magnet attached in the movable part of the buckle. This activates the transmitter in the buckle to transmit the information to the receiver in the ECU wirelessly that the seatbelt is latched [1]. In [2], Light-Emitting Diodes (LEDs) and Complementary Metal–Oxide–Semiconductor (CMOS) cameras are used as transmitters and receivers, respectively. But the suggested seatbelts prove to be costly and large in size.

Data may be transmitted through Radio Frequency (RF) waves with shorter range and reliability. It works exactly like Dedicated Short-Range Communication (DSRC) except the fact that it is a one-way communication system [3]. Alternative communication systems in an automobile system are discussed in [4, 5].

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## 2 Proposed Wireless Seatbelt Latch Status Indicator

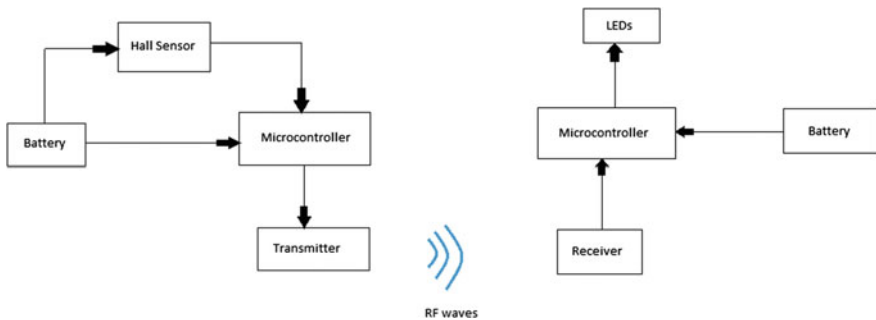
The system consists of transmitter units and one receiver unit. RF waves are used to transmit data. ATmega328p  $\mu$ Controller is used to compute data to be transmitted and processes the data that is received. ATmega328p TQFP is chosen because of its compact size and also because of it being automotive graded.

### 2.1 Construction and Working

The system consists of two units, the transmitting unit and the receiving unit as shown in Fig. 1. Each transmitter is assigned with a unique address, and all the transmitter addresses are saved in the receiver to track which transmitter has currently sent the corresponding data.

**Transmitter Circuit:** It consists of  $\mu$ Controller ATmega328p, which is the heart of the circuit. The clock frequency is set as 8 MHz by connecting 8 MHz oscillator grounded with two 22 pF capacitors. The transmitter circuit is powered by ATmega328p only while data is transmitted, thus conserves energy. The Hall Effect sensor is connected in the input terminal of ATmega328P.

Hall Sensor gives positive output voltage in the presence of a magnetic field and gives 0 V output in the absence of magnetic field. This is given as input to the  $\mu$ Controller. ATmega328p will power up the transmitter only when there is a change in the input, i.e., positive to zero voltage or zero to positive voltage. Once there is a change in the input, the transmitter will read the voltage. If the voltage is positive, the  $\mu$ Controller interprets that the seatbelt is latched up in the buckle. Latched up data and the address data are sent through the transmitter. Once the data transition is done, transmitter turns OFF. And if it is zero voltage, the  $\mu$ Controller interprets that seatbelt is not latched up in the buckle. Unlatched up data and the address data are sent through the transmitter. Once the data transition is done,



**Fig. 1** Block diagram of the complete system, **a** transmitter unit, **b** receiver unit

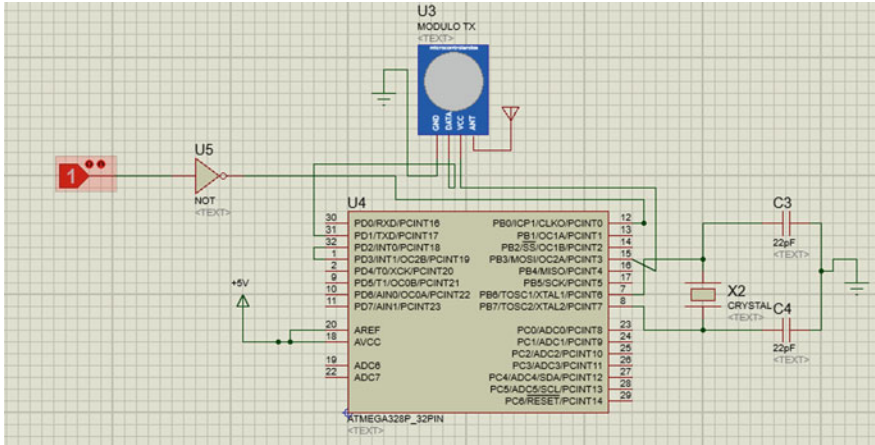


Fig. 2 Transmitter circuit diagram—digital logic state switch is used instead of hall effect sensor

transmitter turns OFF. Power supply for the transmitter is provided by the  $\mu$ Controller as shown in Fig. 2. This helps to overcome the signal clashing problem with too many transmitters.

**Receiver Circuit:** Circuit construction is similar to transmitter circuit with few modifications. Clock frequency is set as 8 MHz by connecting 8 MHz oscillator grounded with two 22 pF capacitors as shown in Fig. 3. The LEDs represent the status of seatbelt. If not latched LED turns ON, and if latched LED turns OFF. More LEDs may be incorporated with each LED representing a seat’s latch status.

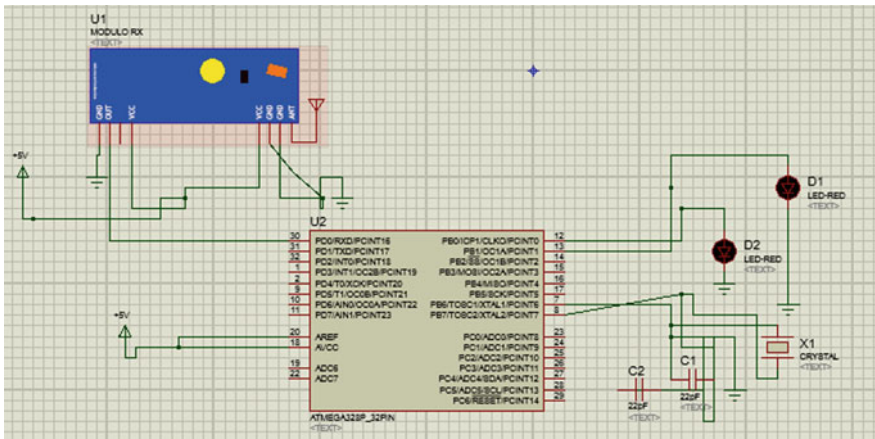


Fig. 3 Receiver circuit diagram—the LEDs, D1 corresponds to transmitter 1 and D2 corresponds to transmitter 2

The receiver always remains in ON state and waits to receive a signal. Signal received is converted to data and sent to ATmega328p.  $\mu$ Controller compares the address with the preloaded addresses and executes the corresponding function that turns ON or OFF the specific LED related to the transmitter's address. The transmitted data is read, and the corresponding LEDs glow. The whole circuit is connected to the ECM board supply unit for power. If the address match does not exist, it erases the data and waits for the signal again.

Coding for both the circuits is done using embedded C++ language in Atmel Studio 7. Simulations are done using Proteus 8 Professional.

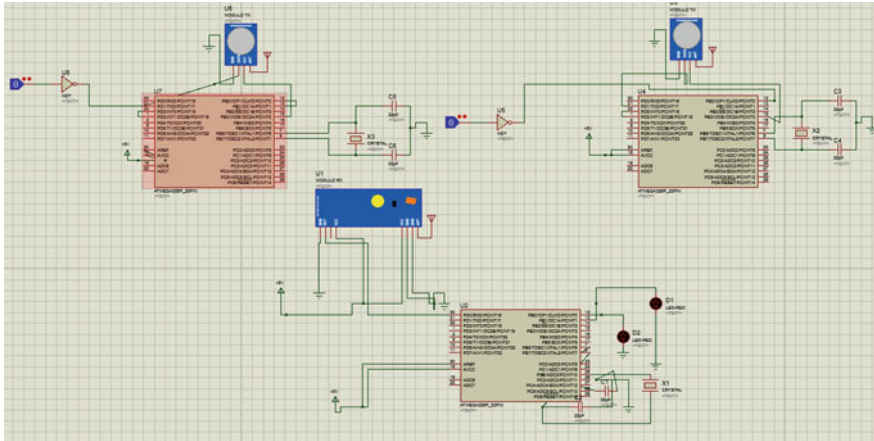
## 2.2 Difficulties Faced

A basic RF transmitter pairs with RF receiver when switched ON. Thus, when another transmitter tries to transmit data to the same receiver, the receiver does not receive the data as it is paired with a transmitter already. In this case not more than one combination of transmitter and receiver is used in a system. This limitation is broken by switching on the transmitter only when there is a data to transmit and remains switched OFF rest of the time. Transmitter requires less than 10 ms to transmit four bytes of data. The first byte is synchronizing byte, second and third bytes are the address bytes, and the fourth byte tells the status of the seatbelt latch, i.e., latched (switched *off*) or unlatched (switched *on*). Multiple transmitters are incorporated in the system now with a single receiver and the chance of signal collision practically is impossible as each transmitter will be switched ON only when there is a change in the status of the seatbelt latch in the buckle.

This RF system falls under short message broadcast category (for *safety* applications) as discussed in [3]. The cost of production can be reduced to a great extent when compared with [2] which uses Optical Wireless Communication (OWC) with LED TX and camera RX. Not only the cost, it is easy to install and eliminate the need of laying wires from the buckle to the ECU in the dashboard of the car, thus making installation process neat and quick. Each car has a unique address and synchronizing byte, this leads to having 16,777,216 cars with unique address. This number can be extended by allotting more address bytes. The speed of the transmission can be improved using 16 MHz crystal oscillator instead of 8 MHz but practically it is said to be less reliable as it can distort more and travels lesser distance than 8 MHz.

## 3 Simulations and Results

Simulations are done in Proteus 8 Professional. Since a magnet cannot be moved during the runtime of the simulation, Hall Effect sensor and magnet are replaced with a digital logic switch that gives 5 V when switched *ON* and 0 V when



**Fig. 4** Wireless seatbelt latch system with one receiving unit and two transmitting units

**Table 1** Inputs and outputs of simulation. Inputs are T1 and T2 (T1—switch state of transmitter 1 and T2—switch state of transmitter 2). Outputs are D1 and D2 (D1 and D2 are LEDs in the receiving unit)

T1	T2	D1	D2
Low	Low	On	On
High	Low	Off	On
Low	High	On	Off
High	High	Off	Off

switched *OFF*. A car may be incorporated with five transmitting units each in different buckles; in simulation, two transmitting units and a receiving unit are shown for simplicity. Each transmitting unit corresponds to a specific LED in the receiver side. The complete simulation setup is shown in Fig. 4.

As there are two transmitters used, there are four different combinations of input that may be given from transmitters as shown in Table 1. Also, it is evident that the LEDs respond inversely to the transmitting unit. This is because when seatbelt is not latched in the buckle, an LED will indicate the driver to fasten the seatbelt, i.e., if T1 is Low, D1 will be switched ON, and vice versa.

**Simulation Outputs:** The output for the four different combinations of inputs is shown in Proteus 8 Professional as shown in Table 1. The results for all the test cases are discussed. Figure 5 shows that receiver’s LEDs are switched ON (Test case 1) when inputs T1 and T2 are Low. Fig. 6 shows D1 turned OFF (Test case 2) as T1 goes high and Fig. 7 represents the vice versa (Test case 3). In Fig. 8, both D1 and D2 are switched OFF (Test case 4) as T1 and T2 are High.

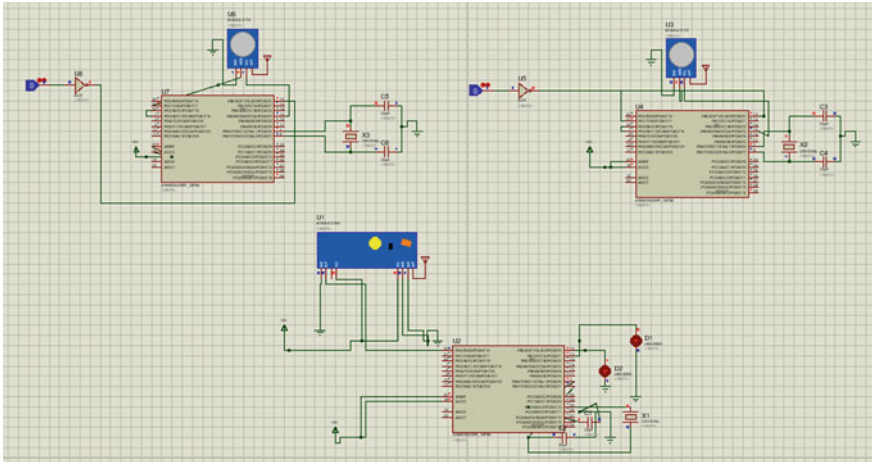


Fig. 5 Test case 1—receiver LEDs D1 and D2 are turned ON as T1 and T2 are Low

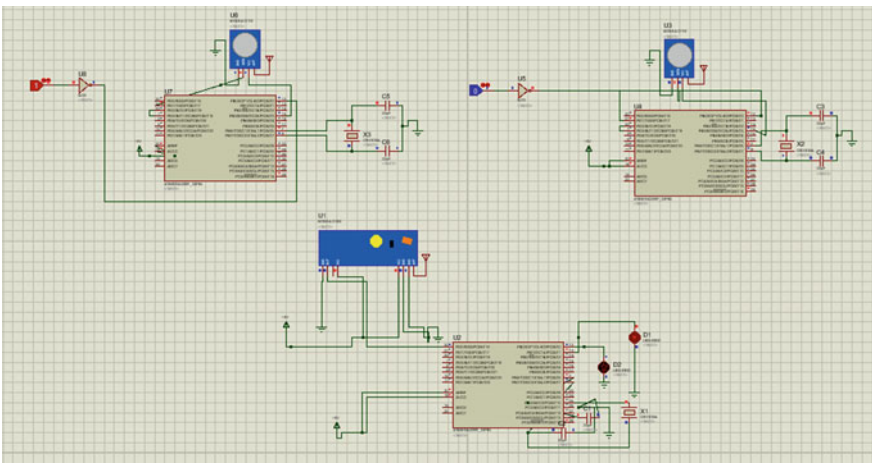


Fig. 6 Test case 2—receiver LED D1 turned ON as T1 alone is Low

### 4 Conclusion

The seatbelt latch status is read wirelessly through RF transmitters. Transmitters are powered by the  $\mu$ Controller that eliminates the signal clashing problem. Addressing transmitters individually make the receivers identify the transmitters and their seatbelt buckle conveniently. The ability to extend the address enables the car

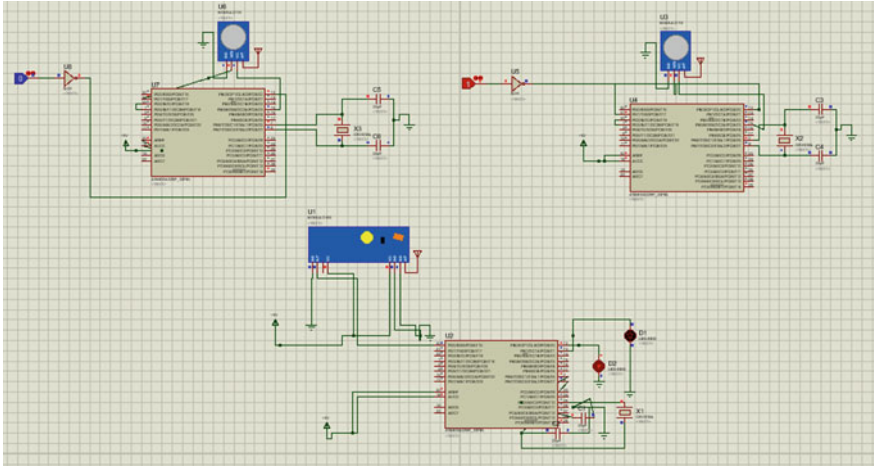


Fig. 7 Test case 3—receiver LED D2 turned ON as T2 alone is Low

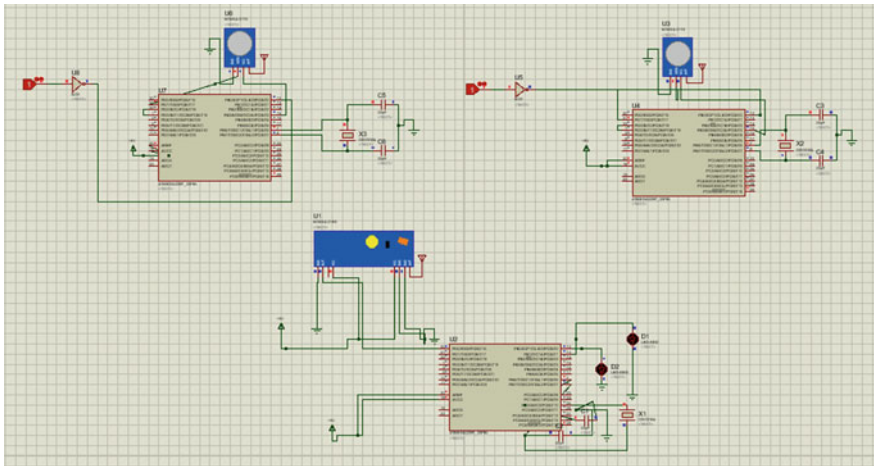


Fig. 8 Test case 4—receiver LEDs turned OFF because T1 and T2 are Low

manufactures to produce more unique addresses. The system is simple to construct making this idea significant. The mentioned points are tested and validated through simulations done in Proteus 8 Professional.

## References

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