

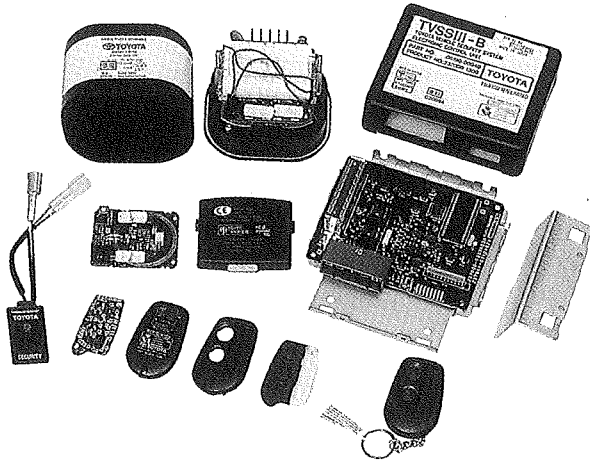
Development for Vehicle Anti-theft System

● Hideo Watanabe

● Manabu Matsubara

● Akira Matsuura

● Norio Tsuruta



Abstract

Automobile theft and the theft of personal property from automobiles is widespread in Europe and North America, among other regions of the world. Heightened interest in automobile security devices on the part of insurers and the public parallels the increase in these crimes. Numerous insurance companies have written special clauses into auto policies favoring vehicles with anti-theft security devices. This, in turn, has spurred a rapid increase in demand for the automobile security systems. However, legal requirements and market conditions for this equipment vary widely from country to country.

The Fujitsu Ten automobile security device has been developed to meet the specific demands of each market. In Europe, it is marketed as an insurance company certified system.

This paper outlines and describes the features of our system for the European and North American markets.

1. Introduction

Since 1984, Fujitsu TEN has been developing vehicle anti-theft systems (referred to as security systems in this document) for 18 countries in North America, Europe, Southeast Asia, and South America. Fujitsu TEN is producing anti-theft systems for mounting on vehicle production lines (OE systems) and for mounting by dealers (optional systems) as genuine parts. There is considerable market demand for security systems in Europe and North America, and the market requirements as they apply to specifications differ depending on where the vehicle is to be sold. This document covers past achievements in the development of products bound for Europe and North America.

2. What Kinds of Security Systems are Available?

Security systems can roughly be classified into alarm systems and immobilizer systems.

2.1 Alarm System

Alarm systems notify people when a theft occurs. If someone attempts to steal a vehicle, audio equipment, other automotive equipment, or personal belongings in a vehicle, the system detects this attempt and issues an alarm to avert it.

2.2 Immobilizer System

To prevent the theft of a vehicle itself, an immobilizer system disables engine startup or prevents its being moved. The system immobilizes a vehicle either electronically by restricting the operation of electric automotive equipment, or mechanically by locking the steering wheel, pedals, or gearshift lever.

3. European Market Trends

3.1 Trends involving European Automobile Liability Insurance Industry

With the reunification of East and West Germany and the collapse of the Soviet Union in the background, the number of vehicle theft incidents rose sharply in Europe. European insurance companies subsequently began to strain under the weight of ballooning insurance claim payments. Around 1991, these insurance companies began pressuring European governments and automobile manufacturers to beef up their anti-theft measures. The insurance companies also began to reduce their amounts of payments on insurance claims for vehicles that were not in compliance with new anti-theft standards, and offering discounts on insurance premiums on vehicles equipped with certified anti-theft systems. As regards the insurance requirements prescribed by the insurance companies and associations of European companies, the unified European standard (95/56/EC) was enacted in 1995.

Table 1 Requirements of representative insurance company, insurance associations, and European standard

	Insurance company, insurance association, and European standard	Requirements
1)	Allianz (German insurance company)	- Insured vehicles shall be equipped with a means of prohibiting engine startup until such means is released by the user with an electronic code using a transmitter, transponder, or electronic key. Allianz requires an electric immobilizer system that stops the ignition or fuel injection system or that activates engine ECU immobility control. To prevent illegal release, the electronic code is required to be a complicated signal. This insurance company prescribes no alarm requirements but immobilizer system requirements only.
2)	Insurance Association of the UK, Insurance Association of Belgium (BVVO), and others	- Insured vehicles shall satisfy not only the immobility system requirements of Allianz in 1) but also alarm requirements. - The alarm requirements include an ultrasonic, radar, or similar sensor to detect entry into the vehicle cabin. - An alarm device shall contain a self-powered siren powered by a built-in battery. Even when the power line is disconnected, the siren must be able to run on the built-in battery.
3)	Insurance Association of Holland (SCM)	- Insured vehicles shall be equipped with a means of prohibiting engine startup until such means is released by the user with an electric code.
4)	95/56/EC (European standard)	- The mounting of an electric immobilizer is mandatory. - This law regulates the alarm sounding time, count (indicating the number of times the alarm sounds), and sound pressure when an alarm system is mounted as well as the use of vehicle safety parts. - Operations for dealing with emergency situations are permitted from inside the cabin only.

Table 1 lists the representative insurance companies, insurance associations, and European standards and summarizes their requirements.

3.2 Security System Required in the European Market

This section covers a security system that lets the user employ a transmitter to lock or unlock doors and set or release the security system.

- 1) System prior to establishment of regulation

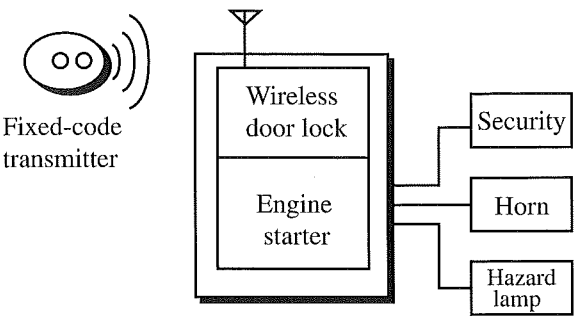


Figure 1 System prior to establishment of regulation

- The doors can be locked with a fixed-code wireless transmitter.
- When the security system enters the alarm state, the system disconnects the line to the engine starter motor and prohibits the engine startup.
- When the security system enters the alarm state, the system causes the horn to blow and the hazard lamps to go on.

- 2) Security system required in Europe

Figure 2 shows systems conforming to the European regulation (95/56/EC).

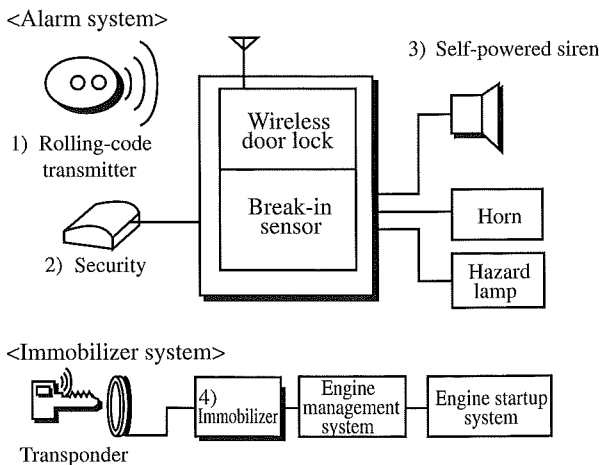


Figure 2 System conforming to European regulation

- 1) The doors can be locked with a rolling code transmitter.
- 2) The sensor detects that someone is breaking into the cabin.
- 3) When the system detects the disconnection of a power cable, the siren powered by the internal battery starts to sound.
- 4) The immobility system prohibits the EFI ECU from starting up the engine.

4. Features of Fujitsu TEN's Security System for Europe

This section goes over optional systems under development for Europe since October 1995.

- (1) Aim of development

Fujitsu TEN aiming to develop a system that will satisfy the requirements of insurance companies in Europe.

- (2) Rolling-code transmitter

- 1) Outline

The transmitter is a remote control device for transmitting the ID code of each user. This device lets the user lock or unlock the vehicle doors and set or release the vehicle's security status. A fixed-code transmitter always transmits the same ID code, but a rolling-code transmitter changes the ID code at each transmission, thereby making a higher level of security available to the user.

- 2) The need for the rolling-code function

With a device called a grabber having code monitor and retransmit functions, it is possible to monitor an ID code transmitted from a transmitter and retransmit it when the vehicle owner is away. Figure 3 shows how this mechanism for illegally releasing the security system is used.

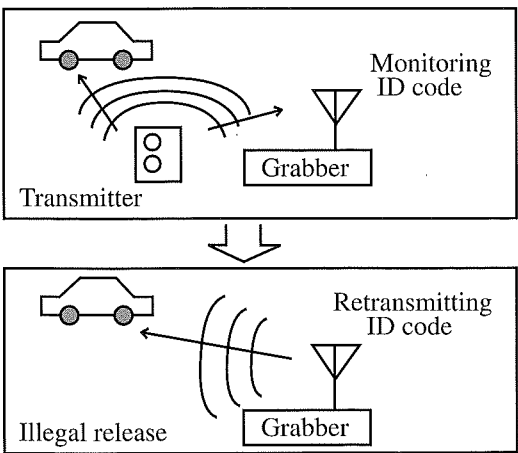


Figure 3 Vehicle theft via use of a grabber

The rolling-code method was devised to prevent illegal system release. A rolling-code transmitter changes the ID code at every transmission and makes an ID code invalid once it has been used.

3) Development of encoding algorithm

The rolling code method can prevent invalid system release by signal retransmission from a grabber. Codes were encoded to prevent code analysis and forgery. The basic encoding techniques involve the substitution of certain characters with others and the modification of the character sequence. Based on these techniques, Fujitsu TEN studied a unique encoding technique and developed an encoding system to make forgery difficult.

(3) Intrusion sensor

Ultrasonic and radio frequency sensors are known for detecting break-ins. For easy mounting via attachment to optional systems, Fujitsu TEN adopted radar sensors as a type of radio frequency sensor that can be installed inside the instrument panel and console.

A radar sensor irradiates microwaves and monitors frequency deviations to detect the presence of moving objects.

1) Radar sensor's principle of operation

If a moving object intrudes into the microwave irradiation range of the sensor, waves reflected from the object show a frequency deviation via the Doppler effect. The type of Doppler-shifted frequency (deviated frequency) that appears depends on the speed of the moving object.

The sensor receives a frequency-deviated reflected wave through the pattern antenna and the mixed circuit fetches only the Doppler-shifted frequency, which it controls as a break-in detection signal.

2) Radar sensor system structure

Figure 4 shows the system structure of the radar sensor.

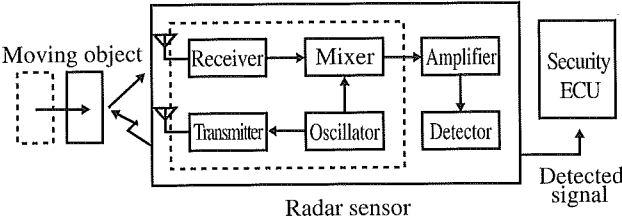


Figure 4 System structure of radar sensor

3) Performance

Figure 5 shows the intrusion detection performance of a vehicle with a radar sensor installed in the center console.

To evaluate the intrusion detection performance, a person's hand was inserted through a window at the speed of 0.4 m/s.

4) System feature

If an intrusion sensor is installed and the security status is set (armed) with a pet inside the cabin, the sensor detects motion in the cabin and triggers an alarm. To avoid this problem from occurring, the intrusion sensor can be turned off with a transmitter.

Table 2 Comparison of radar and ultrasonic sensors

Item	Radar sensor	Ultrasonic sensor
Mountability	This sensor can be installed in the console because microwaves permeate resins.	This sensor requires microphones at the pillars and rearview mirror because resins reflect ultrasonic waves.
Object detected	This sensor detects that a person has broken into the vehicle or that someone is putting their hand in the vehicle. Glass breakage cannot be detected.	This sensor detects that a person has broken into the vehicle or that someone is putting their hand in the vehicle. Glass breakage can be detected from broken pieces of glass and disturbances in the air.
Detection coverage	The detection coverage depends on the distance between the object and the sensor.	If installed at an appropriate position, the sensor can cover the cabin broadly because it detects air movement.
Detection of rain, wind, rolling, or external object	Rain, wind, or rolling does not cause the sensor to malfunction significantly. If the sensitivity is raised, reflections from external objects affect the sensor.	When windows are open, disturbances by the air outside the vehicle can affect the sensor. If the sensitivity is raised, window vibrations can affect the sensor.

Measuring the detection coverage by moving a person's hand and arm from 0.15 to 0.20 m

[Measuring method]

Moving speed: 0.20 to 0.40 m/s
toward the sensor

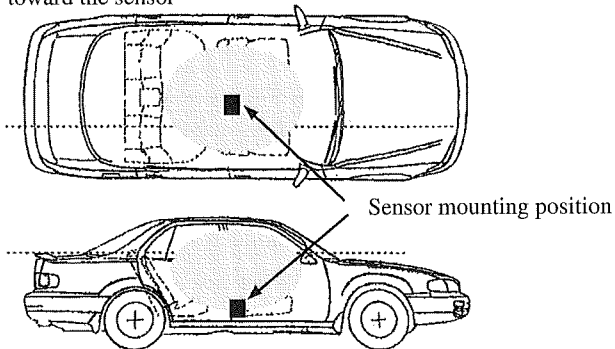


Figure 5 Measurement of break-in detection coverage

(4) Self-powered siren

- The self-powered siren has a internal battery. This battery-powered siren goes on if a signal or power line cut is detected between the siren and the security ECU. This siren is equipped with a 4-bit microcomputer.

1) Structure of self-powered siren

Figure 6 shows the system structure of the self-powered siren.

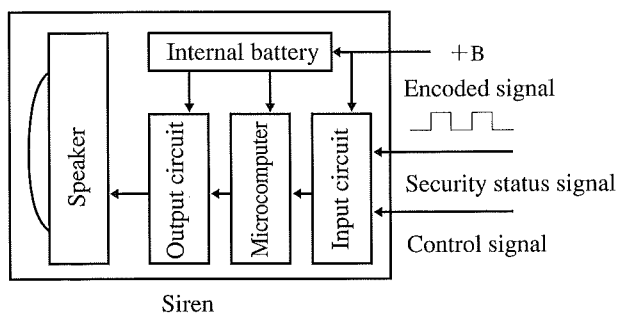


Figure 6 System structure of self-powered siren

Security status signals can be classified into security set (arming) and release (disarming) signals. Control signals are input to control the siren blowing.

2) Characteristics of self-powered siren

The disarming signal is encoded to prevent someone from manipulating a security status signal and releasing the security status (disarming) by inputting the signal. This encoding prevents people from disarming the system by intentionally causing a short circuit with the power or ground line.

The internal battery of the self-powered siren has sufficient capacity to sound the siren for 300 s or more, thereby meeting the requirements of the Insurance Association of the UK.

The ECU-side output circuit has a protective mechanism to prevent the signal output to the siren from being inhibited. This mechanism prevents the destruction of the ECU-side output circuit by using a high voltage to inhibit signal output from the ECU.

The siren also has a bracket that serves as a protective structure to prevent people from accessing and destroying the siren so as to suppress or prevent the siren from sounding.

5. Trends in the North American Market

The trends in the North American market are similar to those in the European market. In some states, the US insurance industry is offering discounts on the premium payment amounts on vehicles equipped with anti-theft systems. These discounts are classified into several categories. If a vehicle has a means of detecting theft, a specific amount is exempted from the insurance premium depending on the content of such system. However, the US insurance industry does not yet have in place standardized (regulated) requirements on security systems as is the case in Europe.

In addition to the basic anti-theft functions (for detecting that a door, trunk, or hood is ajar or the battery line has been cut), general system products on the market have an applied anti-theft function based on the wireless door lock function activated via transmitter control. Many security system manufacturers are developing and selling a large variety of systems. These systems feature the following functions:

1) Mode switching function

- Anti-theft function that can be turned on and off by the user
- 2) Anti-theft sensor
 - Shock sensor and glass breakage sensor
- 3) Optional functions
 - Garage door opener, trunk opener, and other optional functions

Especially for North America, manufacturers are developing products that are based on the user's needs.

6. Features of Fujitsu TEN's products for North America

This section explains the optional systems under development since August 1995.

(1) Aim of development

To meet the user's needs, particularly convenience, Fujitsu TEN aims to develop a system that combines two transmitter-activated functions: a wireless door lock function and an anti-theft function.

(2) System

1) Arming mode switching function

This function allows arming mode to be selected for triggering. One of the following three modes can be selected:

- [1] Security setting using a transmitter
- [2] Security setting using a transmitter + automatic setting (The security status is automatically set when the ignition key is extracted and the doors are closed.)
- [3] Security prohibition (The security status cannot be set.)

Security prohibition is necessary to prevent misoperation of the system that would cause the alarm to sound when, for example, a parking lot attendant who is unaware that the security status is in place attempts to move the car.

2) Multi-car operation function

This function enables a user use a single transmitter to set the alarm status on two vehicles equipped with the same type of anti-theft system. Persons who own two vehicles will not need to use separate transmitters to control the anti-theft systems.

3) Entry delay switching function

Entry delay refers to the time period from when a vehicle door is opened after the security status has been set until the horn blows. During this delay period, the user needs to release the security status with the ignition key. The appropriate entry delay period depends on the user. The user can select one of three delay periods.

4) Ignition-interlocked door lock and unlock function

This function locks all of the doors when the ignition key is used to turn the ignition on and unlocks them when the ignition is turned off. A selection function is also available for inhibiting this function.

This function ensures user friendliness.

5) Glass breakage sensor

Unlike in Europe, neither the insurance industry nor laws in North America make the mounting of a break-in sensor mandatory. Therefore, a glass breakage sensor has been adopted to save on cost and ensure easy mounting.

If any of the vehicle windows are struck with a metallic item, the sensor, as an anti-theft sensor, judges the sound

thus created to result from a break-in attempt. This sensor uses a microphone to collect sound data and detects glass breakage from the signal of a specific frequency via signal analysis. The microphone is mounted on the front of the vehicle instrument panel.

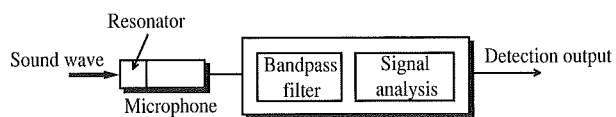


Figure 7 System structure of glass breakage sensor

7. Achievement

In Europe, our anti-theft system cleared the acceptance inspections of the insurance associations of the UK, Holland, and Belgium and became the first system certified by this body that was made by a Japanese manufacturer. The system was tested via durability tests during theft simulations. As for break-in detection, a vehicle window was lowered and a vinyl sheet was affixed in its place. This test was to check whether the system would detect a break-in and theft if the vinyl sheet was ripped and an item left on a seat was removed. There were also attempts to interfere with system components from the outside to see whether the system could be disabled. Fujitsu TEN's system passed all of these examinations.

For the United States, we succeeded in developing a system satisfying user needs with a variety of useful functions comprising an optional anti-theft system that could complement basic anti-theft functions.

8. Future Developments

In Europe, demand will likely continue to exist for improvement and innovation of anti-theft systems so that they can offer higher levels of security performance, thereby satisfying the requirements of the automobile liability insurance industry as well as legal regulations.

North America will probably adopt the European approach in that the automobile liability insurance industry's requirements will be built up, and related legal regulations will be strengthened. The automobile liability insurance industry of Canada is now taking action to establish security standards.

Tracking systems are also becoming more throughout the world. If a vehicle is stolen, its tracking system contacts the control center to assist in locating and tracking it.

9. Conclusion

Anti-theft systems are attracting great attention outside Japan, especially in Europe and North America. These systems are regularly featured in automobile magazines and the subject of discussion at conferences of related associations. These systems are being positioned as key vehicle components. Vehicle sales are even affected by how well they perform.

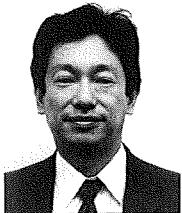
Even in Japan, overseas automobile manufacturers are starting to sell their vehicles with immobilizer systems, and Japanese automobile manufacturers have begun to mount immobilizer systems on their luxury models. Osaka is fast

becoming an unsafe place owing to the increasing frequency with which cars are being stolen by organized criminal groups.

However, enhancing vehicle security should not mean that users have to be inconvenienced. We plan to continue developing products for use throughout the world by enhancing the security without sacrificing convenience (user-friendly products).

We will apply the certified security and transmitter-receiver radio techniques acquired in this development to our future security system development efforts.

Authors



Hideo Watanabe

Joined Fujitsu TEN in 1979. Engaged in development of automotive electronic equipment. Currently serving as a 31 Section manager, Engineering Department 3, Vehicle Electronics Products Group.



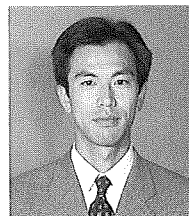
Manabu Matsubara

Joined Fujitsu TEN in 1983. Engaged in development of automotive electronic equipment. Currently assigned to 31 Section, Engineering Department 3, Vehicle Electronics Products Group.



Akira Matsuura

Joined Fujitsu TEN in 1988. Assigned to the Service Department, then temporarily loaned to FTEG in 1992. Currently assigned to 31 Section, Engineering Department 3, Vehicle Electronics Products Group.



Norio Tsuruta

Joined Fujitsu TEN in 1988. Engaged in development of automotive electronic equipment. Has been assigned to FTCA MIO since 1997.