

Research Paper

Design and Application of Electronic Tracking Control Systems (ETCS) to Improve Vehicle Safety

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Abstract

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Fuel and chemical cargo are essential tools for national security. There is the potential for fire and environmental pollution when occurring an accident such as a collision or overturning. On the other hand, cases of cargo theft are also reported frequently. Currently, preventive efforts are carried out by attaching warnings to the vehicle body with stickers, but it is a passive method. Therefore, this article presents a design and application for monitoring vehicles in real time with Electronic Tracking Control Systems (ETCS). If the vehicle speed is more than 60 km/hour, ETCS will send an SMS to the vehicle owner about the speed and location of the vehicle being monitored. With ETCS, vehicle accidents and misuse can be minimized by quick monitoring and communication between the owner and the driver.

Keywords: Fuel and chemical cargo, ETCS, VSMS

Abstrak

Kargo bahan bakar dan kimia adalah sarana penting untuk keamanan nasional. Ada potensi kebakaran dan pencemaran lingkungan ketika terjadi kecelakaan seperti tabrakan atau terbalik. Di sisi lain, kasus pencurian kargo juga sering dilaporkan. Saat ini, upaya pencegahan dilakukan dengan menempelkan peringatan ke badan kendaraan dengan stiker, tetapi ini adalah metode pasif. Oleh karena itu, artikel ini menyajikan desain dan aplikasi untuk memonitor kendaraan secara real time dengan *Electronic Tracking Control System* (ETCS). Jika kecepatan kendaraan lebih dari 60 km/jam, ETCS akan mengirim SMS ke pemilik kendaraan tentang kecepatan dan lokasi kendaraan yang dimonitor. Dengan ETCS, kecelakaan dan penyalahgunaan kendaraan dapat diminimalkan dengan pemantauan cepat dan komunikasi antara pemilik dan pengemudi.

Kata Kunci: Kargo bahan bakar dan kimia, ETCS, VSMS

1. Introduction

Currently, cargo security has become a priority for the development of automotive technology due to road traffic accidents by the driver's neglect of standard procedures or theft cases [1]. Over the past ten years, traffic accidents in Europe have reached more than ten thousand

incidents. To solve this problem, countries in Europe are committed to reducing the number of crashes with integrated technology [2]. Meanwhile, the number of dead accidents in Indonesia in 2017 has reached more than 30000 cases [3]. On the other hand, theft of commercial and passenger vehicles, as well as cargo theft,



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often occurs, which is a concern for vehicle owners and transportation service owners.

During the last decade, there have been efforts to develop vehicle safety systems such as braking technology with auto control on Electronic Vacuum Booster (EVB) [4]. EVB makes it possible to control hydraulic pressure on the brake system more gently. Furthermore, to prevent brake system failures, Support Vector Machine (SVM) technology was developed [5], and more commonly, Anti Blocking System - (ABS) was developed [6]–[8]. ABS allows the vehicle to run more safely despite sudden braking. More modern, for vehicles with autonomous systems, have implemented security braking [9], [10]. Other safety systems that can work not only improve driving safety but can regulate fuel consumption [11], [12].

For now and in the future, information and digital technology have begun to be applied in vehicle safety systems. One of them is the utilization of the Global Positioning System (GPS) as a feature of the security system to monitor the position of the vehicle so that that vehicle abuse can be minimized [13]. Another security system method is the use of the Atmega-8 microcontroller and the HC-06 Bluetooth sensor, which is connected to an android device to prevent vehicle theft [14]. However, this can only be used to track the position of the vehicle but has not been able to monitor vehicle speed.

The use of sensors in the security system was also applied, including the application of an AT89S52 microcontroller-based passive infrared sensor, which uses human body heat as a detector. The detected signal will be processed by the controller and give a message to the vehicle owner by sending a miscall [15]. Unfortunately, this technology is not yet efficient for the actual operating vehicle. Security system technology with monitoring methods is also experiencing growth. Among them, the application of vehicle position tracking systems with GPS and GPRS technology based on websites. This technology will send the location of the vehicle through the website with an accuracy rate of 99.92% [16]. This method can only be used to track the location of the vehicle but has not been able to monitor vehicle speed.

Furthermore, vehicle speed monitoring technology based on driver behavior has also been

developed [17]. With the existence of the Vehicle Safety Management System (VSMS) technology, the system has been able to warn the driver and the owner of the vehicle or supervisor if the vehicle goes beyond the permitted speed. This technology uses a microcontroller and GPRS Shield. This system is better than the previous system but has not been used reliably to detect vehicle locations. Therefore, this research integrates a system to monitor vehicle location and vehicle speed to reduce the potential for accidents, especially for fuel and chemical cargo.

2. Method

The development of ETCS considers the input, control, and actuator factors developed from previous research systems [17]. ETCS added a vehicle position tracking system to find out the vehicle's position. There are three components used in the development of ETCS, namely the Throttle Position Sensor (TPS), Vehicle Speed System (VSS), and Global System for Mobile Communication (GSM). TPS generates a signal about the throttle valve opening angle, VSS generates a vehicle speed signal, and GSM is used to provide the vehicle's position when tracking. GPRS shield functions as a provider of information to vehicle owners when the vehicle is running beyond the speed limit. The information sent is an SMS through the cell phone of the vehicle owner to monitor in real-time the vehicle being operated.

ETCS can provide information to vehicle owners about vehicle position and vehicle speed through chips that are installed in the control system. The control system works in conjunction with a microcontroller that has been programmed based on system requirements. The position of the vehicle can be tracked via google maps which can be seen when needed by the vehicle owner. Signal conditioning functions as filtering on the output signal generated by the VSS and TPS sensors. Microcontroller works based on a digital system. Therefore, the analog signal generated by the sensor requires an Analog to Digital Converter (ADC) device. Filters installed on the sensor make it possible to eliminate noise that occurs due to interference from the environment. The ETCS block diagram is presented in [Figure 1](#).

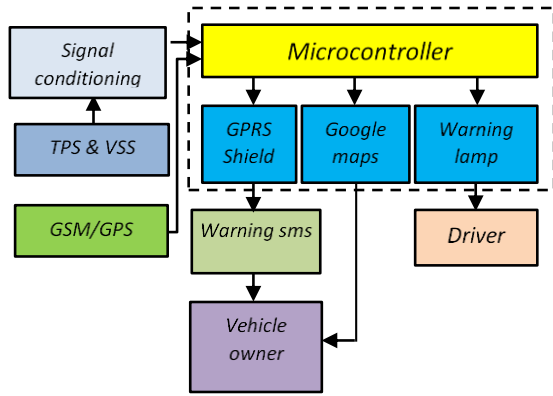


Figure 1. Block diagram of ETCS

Furthermore, ETCS is made through several stages, namely making wiring diagrams, embedded processes, testing, and verification. The ETCS circuit is verified for component connectivity inspection. The embedded system is verified through microcontroller coding inspection. The coding program that is embedded in the microcontroller is made using C language. The implementation of the test media is verified by the performance of the ETCS output on the control system design. Test media inspection is verified through its ability to provide information via SMS when the vehicle exceeds the speed limit (60 km/h) and tracking the vehicle's position. The flow chart of the verification process for each step is presented in Figure 2.

The signal quality generated by TPS and VSS sensors is verified by an oscilloscope. Analog signals are converted to digital signals with the ADC in the microcontroller. The ability of a microcontroller to process ETCS data depends on

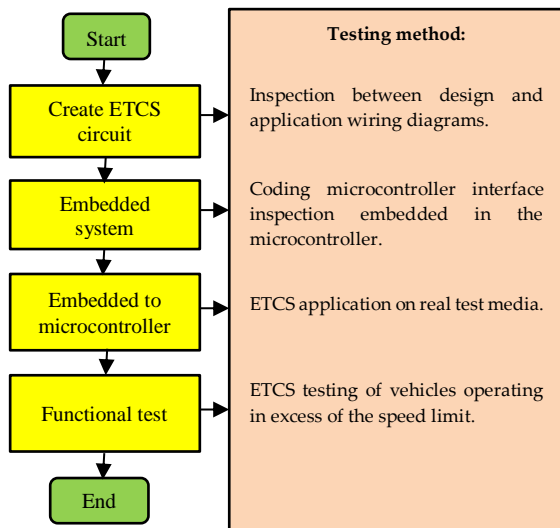


Figure 2. Step of the verification process

the capacity of Read Only Memory - ROM, Random Access Memory - RAM, and flash memory. The specifications of the microcontroller used in the study are presented in Table 1.

Table 1. Specification of microcontroller

No.	Item	Specification
1.	Type	ATmega328
2.	SRAM	2 KB
3.	EEPROM	1 KB
4.	Flash Memory	32 KB
5.	Pin Digital I/O	16
6.	Pin Analog	6
7.	Input voltage	7 – 12 volt

3. Result and Discussion

3.1. Wiring diagram of ETCS

The development of ETCS is a continuation of the VSMS system has been carried out in previous studies [17] with the addition of GPS tracking. This technology was developed with a warning system via SMS to vehicle owners if the vehicle goes more than 60 Km / hour. SIM808 Module as a device in the GPS control system will produce information that will be processed by the microcontroller. This device sends data to the vehicle owner via SMS.

SMS is sent by the ETCS control system to the vehicle owner via RX and Tx pins in collaboration with GSM/GPRS SIM 808. GPRS can also send SMS and provide information about the vehicle's location. SMS sending using the GPRS controller which consists of a microcontroller to process data in real-time. C language coding is embedded into the microcontroller based on the design of programming instructions. Wiring diagrams of system design are presented in Figure 3.

3.2. TPS and VSS Signal

The signal generated by the TPS sensor is received by the controller about the throttle valve opening angle (%). This sensor produces an analog signal with a 5 volt feed and a trigger between 0 to 4 volts. Signal characteristics generated by the TPS sensor are continuous, periodic and linear. This TPS signal is converted by ECTS to 0-1023.

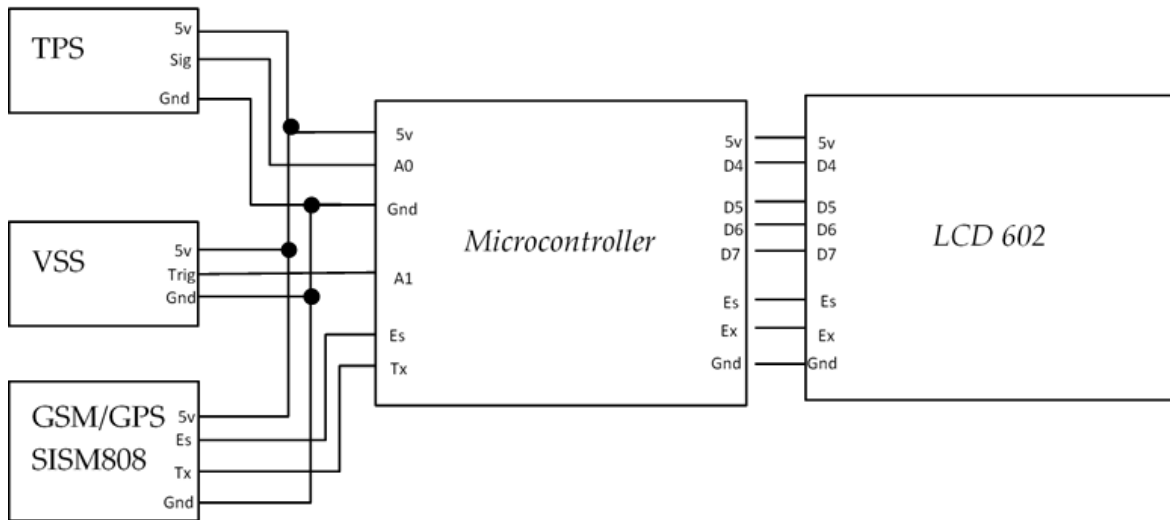


Figure 3. Wiring diagram of implemented ETCS

Furthermore, the VSS sensor generates digital signals that have values 0 and 1. After the amplification process, the value of the VSS sensor reaches more than 2 volts so that it can be processed to the actuator. If the transmission speed increases, the number of pulses generated by the VSS sensor also increases, and vice versa. VSS pulses are set at 500 bits at a speed of 60 km/h, so when the VSS sensor generates pulses above 500 bits, the controller will send an SMS to the vehicle owner. The controller programming logic is presented in Table 2.

Furthermore, the prototype testing was carried out at 20° downhill and 25° uphill. Data on throttle valve position and vehicle speed in the ETCS are presented in Figure 4 and Table 3, respectively. The green arrow in Figure 4 shows the ECTS limit.

Table 2. Logic of ETCS Controller

No	ETCS control System	Signal sensor VSS	Signal sensor TPS
1.	On	Many	Low
2.	Off	Medium	Low
3.	Off	Little	Low
4.	On	Many	Medium
5.	Off	Medium	Medium
6.	Off	Little	Medium
7.	On	Many	Medium
8.	On	Many	High
9.	Off	Medium	High

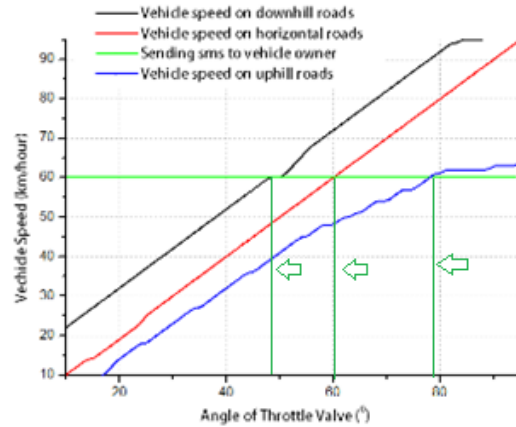


Figure 4. Position of the throttle valve and vehicle speed on ETCS.

Table 3. Throttle valve position and vehicle speed in the ETCS

No.	Throttle angle (%)	Vehicle speed (km/h)		
		Downhill	Uphill	Flat
1	10	22	5	10
2	15	27	8	14
3	20	32	14	19
4	25	37	18	25
5	30	42	23	30
6	35	47	27	35
7	40	52	32	40
8	45	57	36	45
9	50	60	41	50
10	55	67	45	55
11	60	72	48	60
12	65	77	51	65
13	70	82	54	70
14	75	87	57	75
15	80	92	61	80
16	85	95	62	85
17	90	96	63	90
18	95	97	64	95

3.3. Data Tracking ETCS

ETCS can be used by opening google maps installed on a cell phone or android with a number that is connected to the control system. To track a vehicle, the owner simply writes on google maps, the vehicle position will appear in the Latitude and Longitude coordinates. Examples of vehicle location tracking results are presented in Figure 5. Examples of vehicle location tracking are

presented in Figure 5. In addition to being displayed in the form of "capture", tracking data can also be displayed in tabular form, as presented in Table 4.

Finally, this ETCS can function properly if the vehicle is in an area with a good cellular network. If the area traversed by the vehicle does not have a good cellular network, the process of sending data via SMS or tracking through Google Maps will be disrupted.

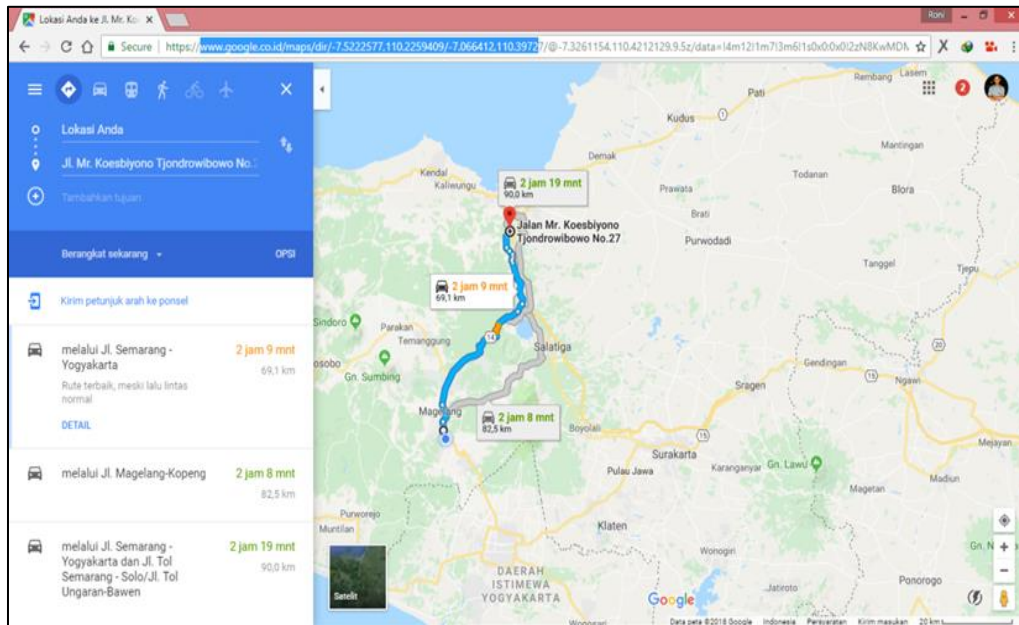


Figure 5. Location of a tracked vehicle

Table 4. Tracking position data and google map link on ETCS.

No.	Vehicle speed (km/h)	Position (Latitude,Longitude)	Delivery to cell phone
1.	60	7°03'59.1", 110°23'50.2"	Your vehicle is exceeding speed http://www.google.co.id/maps/place/-7.066412S110.397270E
2.	70	7°03'59.1", 110°23'50.2"	Your vehicle is exceeding speed http://www.google.co.id/maps/place/-7.066412S110.397270E

4. Conclusion

Based on testing the ETCS prototype on the vehicle, some notes need attention. When the vehicle speed exceeds 60 km/h, ETCS will send information to the vehicle owner via SMS in real-time, so vehicle monitoring can be done automatically. However, this ETCS also has some weaknesses, the signal generated by the controller depends on the cellular service installed on the

android/cell phone. If the vehicle operates in an area where cellular networks are not available, information to the cell phone/android of the vehicle owner will be problematic. Therefore, this research will continue with a signal system that can be sent via satellite, so that the coverage area can be expanded and the loss signal can be minimized.

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