Journal of Physics: Conference Series **1444** (2020) 012037 doi:10.1088/1742-6596/1444/1/012037

Design and development of multi media cards as a motorized vehicle speed data recorders

Dwi Purwanti*, Djoko Adi Widodo, Noor Hudallah, Arief Arfriandi, Riana Defi Mahadji Putri, Sugeng Purbawanto, Isdiyarto, Hari Wibawanto, Muhammad Harlanu and Anggraini Mulwinda

Department of Electrical Engineering, Universitas Negeri Semarang, Indonesia

*Corresponding author's e-mail: ithoeq_depe07@yahoo.com

Abstract. The purpose of this study is to design and make a prototype of a motorized vehicle speed data recorder by utilizing MMC (Multi Media Card) as a data recording media so that there will be factual evidence in the form of a motor vehicle track record as long as the vehicle is running. The research method uses the Research and Development (R & D) approach, with stages: hardware design and firmware creation, hardware testing, GUI application creation, GUI application testing, data retrieval testing, and data analysis. The entire system of this tool is controlled by the ATmega328 microcontroller, the RTC module is used to generate timer signals in real time and Infrared Sensors (IR Sensors) as wheel rotation detectors that are used as car speed sensors when driving. Data is recorded in the form of real time speed, accelerator (acceleration) and the distance stored in a Secure Digital Card (SD Card) or MMC (multimedia card) within the specified time interval. The results of hardware testing show that the design works through all the test scenarios performed. GUI applications and firmware are tested by blackbox testing, and show that the system is running smoothly. In addition, testing is also focused on speed data recording segmentation algorithms, with the result that the algorithm can mark the phase of each speed change with 100% accuracy. Product testing with data retrieval is done in 10 (ten) data by comparing the actual distance indicated by the speedometer with the system measurement value. The test results show that the system can accurately estimate activity parameters for each change in speed, with an accuracy rate of 98.91%. In addition, the standard deviation value of 0.02625 km / h indicates that this system is considered consistent in measurement.

1. Introduction

The number of motor vehicle accidents in Indonesia is very high, and has become the number 3 cause of death [6], even according to Hayes [5], Cited by Abdallah Kassem [1] stated that according to the World Health Organization, every year more than one million people in the world die from transportation-related accidents. The road traffic law in Indonesia has not yet required vehicles to use speed markers that can be marked by observers both inside and outside the vehicle so that when the car passes or if an accident cannot be determined exactly how fast the car is at that time. In a number of previous studies many efforts have been made to make a tool that is able to contribute to making motorists more careful in running their vehicles. The research was carried out among others by Tomer Toled [9], who examined the In-Vehicle Data Recorder for Evaluation of Driving Behavior and

Journal of Physics: Conference Series **1444** (2020) 012037 doi:10.1088/1742-6596/1444/1/012037

Safety, Abdallah Kassem [1] who made the VBBS Vehicle Black Box System, and Dwi Purwanti [4] who made a prototype of a motorized vehicle speed marker on the highway.

Dwi Purwanti (2012) in the study made a prototype of the speed marker tool whose installation was focused on the outside of the car body and inside the car, so that observers outside and inside the car could monitor the speed of the car at that time. Sign lights and sound displays that are made indicate the speed of the car at a certain speed range. Thus outside observers, especially the police, will soon find out if the speed of the car exceeds the allowable limits, and violators of the speed limit will be subject to sanctions. However, the indicator lights and alarms only sound when the car is running, so that it cannot be used as permanent evidence for the police to ensnare the driver who violates this speed limit with legal sanctions, so that an authentic evidence tool is needed in the form of a running track record of motorized vehicles at that time. Therefore in this study a prototype of a motorized vehicle speed data recorder was made using MMC (Multi Media Card) as a recording media and supported by several other components. It is hoped that by recording the speed of these motorized vehicles that can be displayed at any time when needed, it will be very helpful for evidence of accidents and other interests.

The specific purpose of this research is to uncover and find the following:

- Can be designed Prototype Motor vehicle speed data recorder with speed data recording media using MMC (Multi Media Card)
- From the prototype that has been designed, an electrical test data analysis can be carried out and a limited test of the accuracy and practicality of the tool.

Overall the system of this tool is controlled by the ATmega328 microcontroller, the RTC module (Real Time Clock) is used as a timer signal generator in real time, the Infrared sensor (IR Sensor) functions as a wheel rotation detector used as a car speed sensor when driving. Data recorded is in the form of real time speed, accelerator (acceleration) and distance traveled stored in MMC (multimedia card) in the time interval that can be set through the application menu. The diagram block of the motorized vehicle speed data recorder is described as follows:

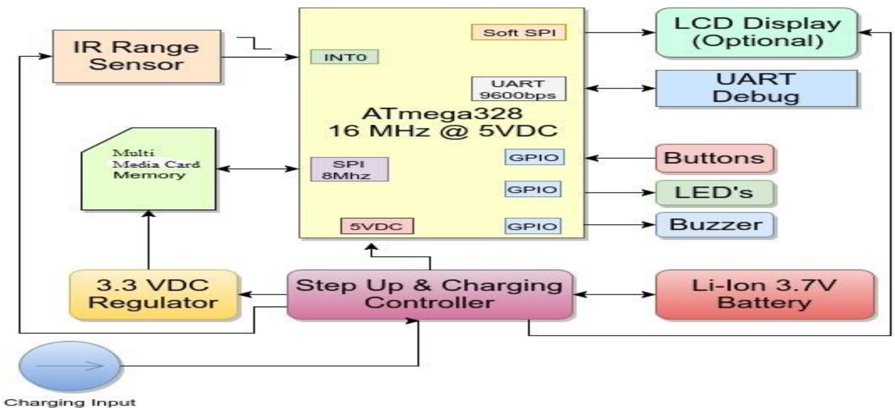

Figure 1. Diagram Block Prototype of Motorized Vehicle Speed Data Recorder Tool

2. Multi Media Card (MMC)

The Multi Media Card (MMC) is a memory-card standard used for solid-state storage. Unveiled in 1997 by SanDisk and Siemens AG [8]. MMC is based on a surface-contact low pin-count serial interface using a single memory stack substrate assembly, and is therefore much smaller than earlier systems based on high pin-count parallel interfaces using traditional surface-mount assembly such as CompactFlash. Both products were initially introduced using SanDisk NOR-based flash technology. MMC is about the size of a postage stamp: 24 mm × 32 mm × 1.4 mm. MMC originally used a 1-bit serial interface, but newer versions of the specification allow transfers of 4 or 8 bits at a time. MMC can be used in many devices that can use Secure Digital (SD) cards.

3. Microcontroller

A microcontroller is a single-chip computer that is specifically manufactured for embedded computer control applications. These devices are very low-cost and can be used very easily in digital control applications. Most microcontrollers have the built-in circuits necessary for computer control applications. For example, a microcontroller may have A/D converters so that the external signals can be sampled. They also have parallel input–output ports so that digital data can be read or output from the microcontroller. Some devices have built-in D/A converters and the output of the converter can be used to drive the plant through an actuator (e.g. an amplifier). Microcontrollers may also have built-in timer and interrupt logic. Using the timer or the interrupt facilities, we can program the microcontroller to implement the control algorithm accurately. [7]

ATmega328 microcontroller is an Atmel production microcontroller that uses the core CMOS (Complementary Metal Oxide Semiconductor) (core) and has an 8-bit AVRR RISC architecture [2] ATmega328 is identical to ATmega48, ATmega88 and ATmega168, all four have the same electrical specifications and pin out. The only difference lies in the amount of RAM and ROM. There is also a version with suffic -P which has the advantage of lower power consumption. In designing the prototype of the Car Speed Marker, researchers used the AVR ATmega328 type microcontroller which has advantages over other types of microcontrollers. the advantage of the AVR microcontroller is that AVR has a faster program execution speed because most instructions are executed in a 1 hour cycle, faster than the MCS 51 microcontroller which has a CISC (Complex Instruction set Compute) architecture where the MCS 51 microcontroller requires 12 cycles to run 1 instruction.

4. RTC (Real Time Clock)

RTC (Real Time Clock) is an IC (Integrated Circuit) that is specifically designed in the timing process such as hours, minutes, seconds, dates, months, years, etc. This device functions as a digital clock that is used as a clock for this system used for speed data at that time. With this device, it will be known the speed data that is shown also the time at the time of the speed record. RTC on the system is a timer system that can be retrieved data in I2C communication. I2C communication system allows to use 2 lines so that reducing cable usage. Besides that, I2C communication has also been more popular through the development of increasingly developing technology. [10]

5. Infra Red Sensor (IR Sensor)

Basically the Infra Red Sensor is a proximity sensor, so the speed calculation mechanism resembles a speed encoder in general. The IR sensor unit comprises IR LED which emits a high intensity red light out of the sensor unit. If the obstacle is in its path it was received and the light was received by the transistor photo. The reflected signal falls on the photo transistor. This ray excites the transistor and switches on the transistor. [3]

In this study when the wheel rotates, the alloy wheels will trigger the IR sensor so that it outputs a digital signal with the wave box characteristics corresponding to the speed of the wheel. When the IR sensor hits the alloy bar, the IR sensor will detect the object in front of it so that the output will be LOW and the sensor does not hit the alloy bar, the IR sensor cannot detect the object in front of it so the output will be HIGH. This wave box will be forwarded to the recording device.

Journal of Physics: Conference Series **1444** (2020) 012037 doi:10.1088/1742-6596/1444/1/012037

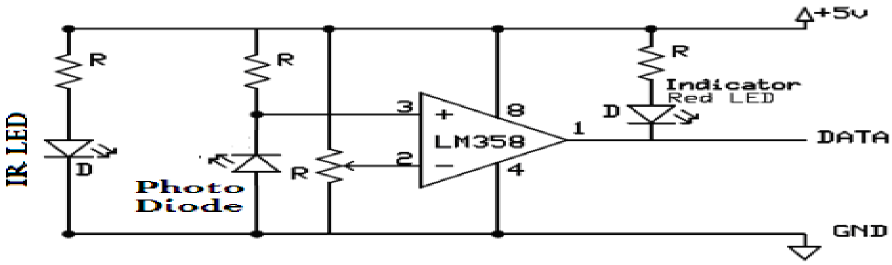

Figure 2. Working Logic of IR Sensors

6. Research Methods

The research method used is Research and Development with product output in the form of motorized vehicle speed data recorder hardware and speed data recording software. The research stages are described as follows:

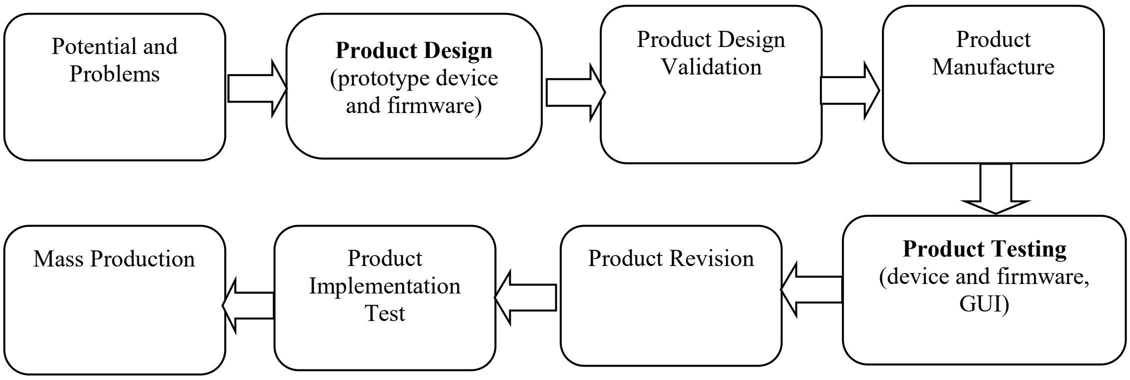

Figure 3. Stages of Research

6.1. Tools and Materials

Below are the main tools and materials used in this study:

Hardware

- Computer: Processor Intel Core i3-370M 2.4 GHz, RAM 8Gb.
- ATmega328 Microcontoller.
- SanDisk MMC 8Gb, equipped with fullsize adapter
- InvenSense MPU-9150 Module
- Single cell 3.7 VDC Li-Ion battery.
- Step-up module and charger for batteries.
- 3D printer type cartesian along with PLA filaments.
- USB to UART converter module.
- Infra Red Sensor

Software

- Manjaro Linux 16.10 Fringilla 64-bit: Kernel x86_64 Linux 4.4.45-1-MANJARO, XFCE4 desktop environment.
- Qt Creator version 4.2.1: Qt Framework version 5.7.0,
- PulseView (https://sigrok.org/wiki/PulseView).

7. Results and Discussion

7.1. Product Design Result
The overall product design results can be described through the following flowchart:

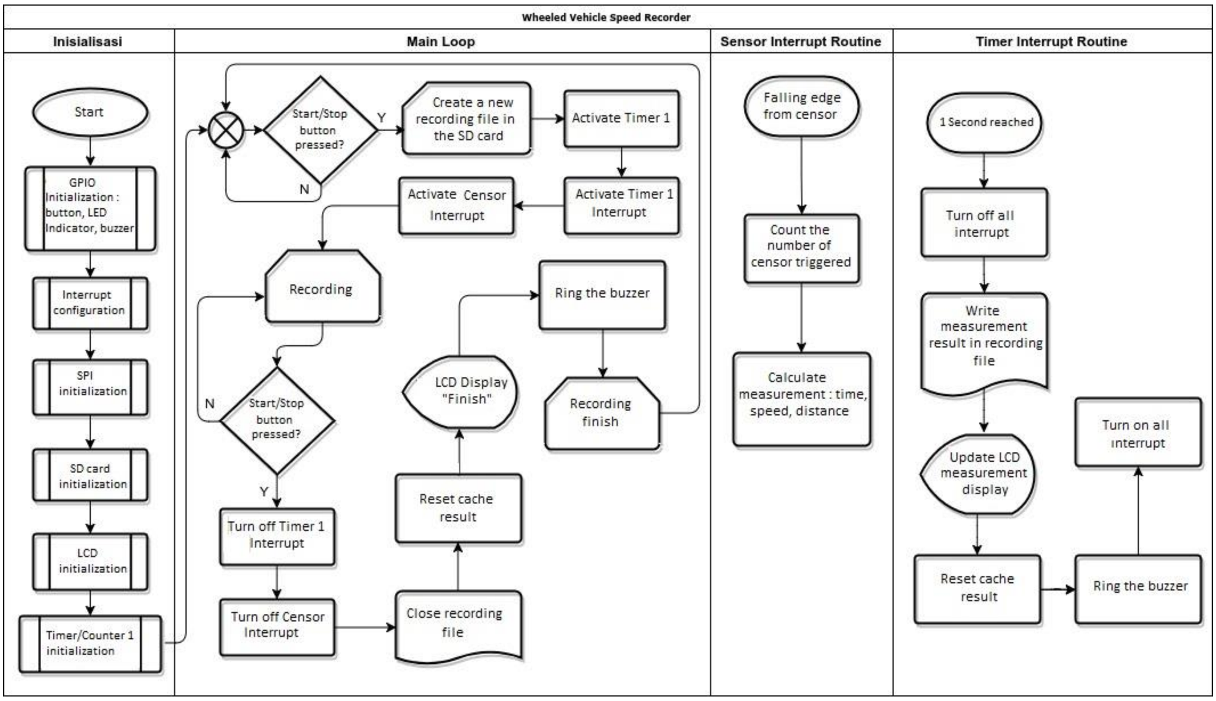

Figure 4. Design Product Flowchart

7.2. Product Making Result

7.2.1. Recorder Hardware. Motorized Vehicle Speed Data Recorder Tool consists of the main components of the hardware namely the Infra red sensor, MMC Slot Adapter, Microcontroller, power button, connecting cable and firmware software in the recording device.

7.2.2. Display and GUI Application. GUI application results that have been made can properly process raw binary files from hardware and then present them in the form of informative data. Data is presented both in numerical and graphic form so that it is easy to read. The following is the appearance and features of the GUI application.

Menu Bar

Contains actions to open prototype log files (Load Raw Record) and export data tables into Excel Spreadsheet format (Export Records as Xlsx). Menu bar display as follows:

Figure 5. Menu Bar

The menu bar that places it in the upper left corner of the application window can be seen directly by the user once the application is executed, so the user will easily access the essential actions, namely: loading log files and exporting log files in spreadsheet format.

Data Presentation Navigation Display

Function to change the appearance of data presentation between instrument display and table view. Below is a data presentation navigation display:

Figure 6. Data View Navigator

Data presentation navigation display is made with Tab View control. Use of Tab View provides "one-click" access, making it easier for users to change the presentation display between view table and instrument display.

Instrument Display

This is the display of data presentation when the program starts or can be called the default display from the GUI. In this display various instruments are presented in the measurement data. The design results are shown in this Figures, users can observe various types of information on the recording activity of the speed using this feature.

7.2.3. Numerical Data Instrument

Function displays various momentary parameters in numeric form. The font used is the seven segment form to make it look clearer. Below is the display of numerical data instruments:

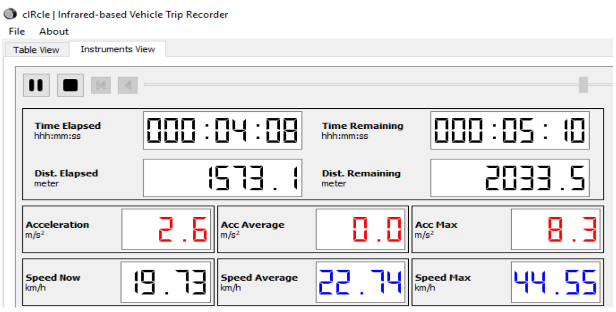

Figure 7. Numerical Data Instrument

7.2.4. Number Chakra Instrument

In addition to the display of numerical data instruments, there are also display of numeric discs to display the parameters of vehicle acceleration and vehicle speed. Display number disks are useful when data acceleration and vehicle speed change fluctuatively.

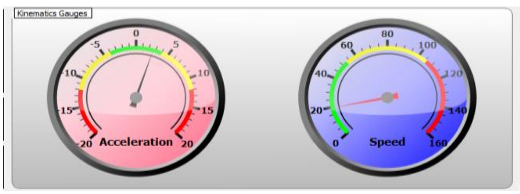

Figure 8. Number Chakra Instrument

By looking at the number disc instrument, fluctuating acceleration and speed values can be concluded more easily by the user than seeing it through numerical data instruments. The scale value of numeric discs is set at a distance, namely - 20 m/s2 to 20 m/s2 for vehicle acceleration discs, while for disc numbers the speed is 0 km/h to 160 km/h.

7.2.5. Speed and Acceleration Curves in the Time Domain

To see how the movement of values from time to time, also provided a data display in the form of a curve (figure 9). This curve displays the value of changes in vehicle speed (blue curve) and vehicle acceleration (red curve) in the time domain with a per grid interval of 10 (ten) seconds.

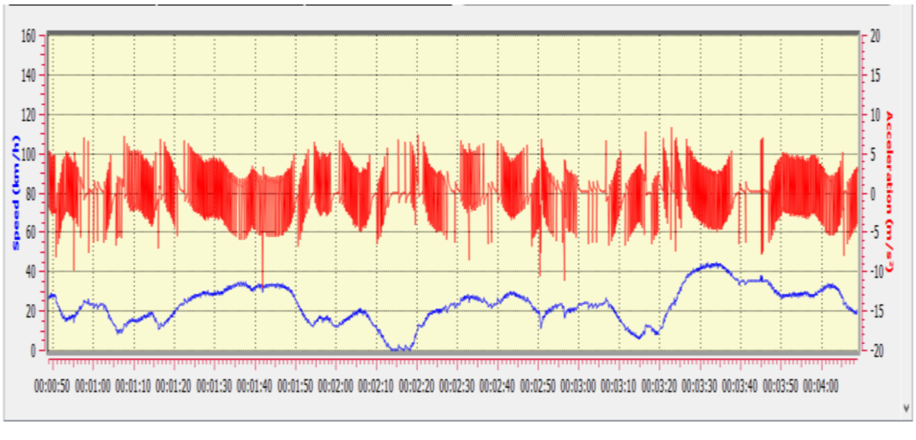

Figure 9. Speed and Acceleration Curves in the Time Domain

The speed of the y-axis velocity is fixed, namely the interval 0 km/h to 160 km/h with a grid width of 20 km/h. While the y axis for acceleration is set with a range of - 20 m/s2 up to 20 m/s2 following the full scale range of the accelerometer set with a range of ± 4 grids.

7.2.6. Distance Curve in Time Domain

Serves to observe changes in distance over time. Unlike the speed and acceleration curves, the scale of the y axis on the time curve is automatically adapted to the continuous increase in mileage.

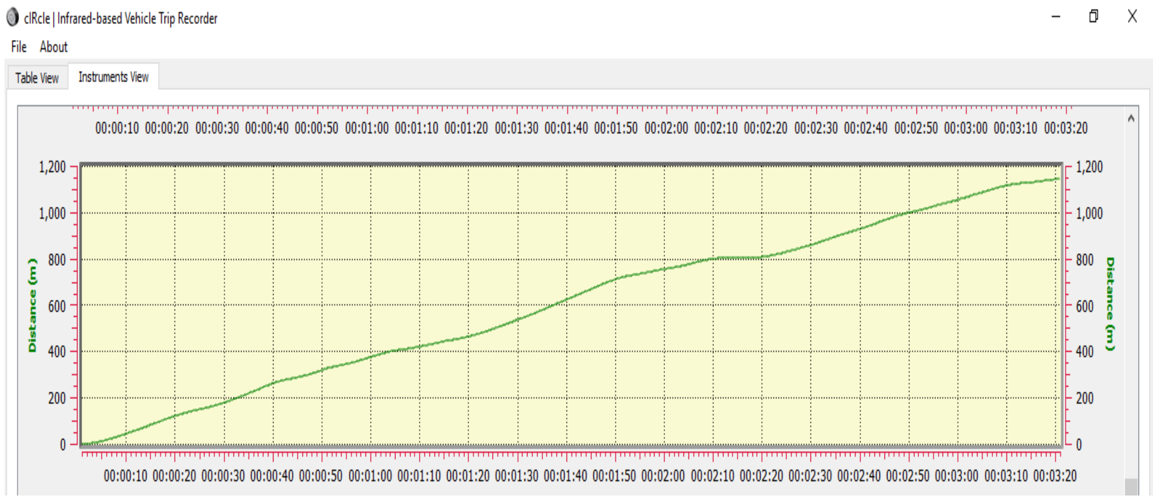

Figure 10. Distance Curve in Time Domain

7.2.7. Histogram Speed and Acceleration Graph

The feature of speed and acceleration histogram graphs is a rod-shaped graph that describes the distribution of data frequency velocity and acceleration in the percentage value. The class width displayed is 0.5 km / h. Through this graph the user can conclude the distribution of the speed and acceleration values that are most often achieved while the vehicle is running. The speed and acceleration histogram graph has the following appearance:

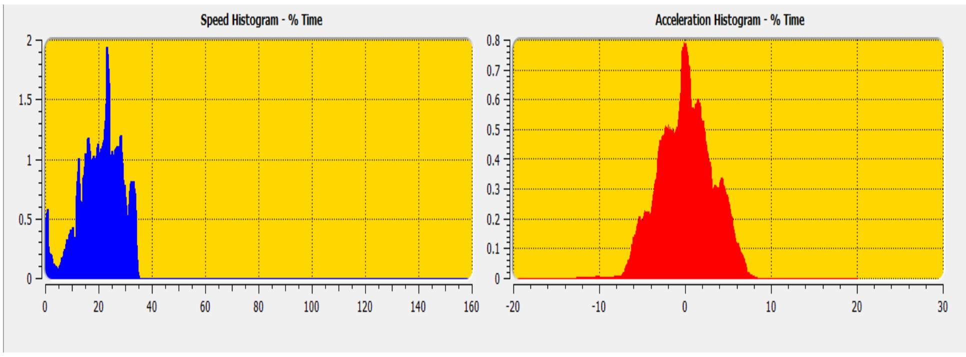

Figure 11. Histogram Speed and Acceleration Graph

7.2.8. Data Export Feature

This feature serves to record data in table form into a spreadsheet file. The standard spreadsheet file used is Microsoft Excel 2007-2013 XML with an extension (.xlsx). This export file is useful for reviewing travel activities that have been carried out with the aim of knowing the characteristics of travel from time to time without having to reopen the GUI application. Below, fill in the export file sheet that was opened using Libre Office Calc version 5.1.6.2.0+:

Time Elapsed (hhh:mm:ss:ms)	000:09:19:800
Overall Average Speed (km/h)	23.190
Speed Maximum (km/h)	44.545
Distance Elapsed (m)	3606.658

Time Elapsed (hhh:mm:ss:ms)	Time Remaining (hhh:mm:ss:ms)	Rotation Rate (rpm)	Acceleration (m/s^2)	Speed (km/h)	Average Speed (km/h)	Distance Elapsed (meter)	Distance Remaining (meter)
000:00:00:000	000:09:19:800	0.00	0.0000	0.000	0.000	0.000	3606.658
000:00:00:100	000:09:19:700	0.00	0.0000	0.000	0.000	0.000	3606.658
000:00:00:200	000:09:19:600	0.00	0.0000	0.000	0.000	0.000	3606.658
000:00:00:300	000:09:19:500	0.00	0.0000	0.000	0.000	0.000	3606.658
000:00:00:400	000:09:19:400	0.00	0.0000	0.000	0.000	0.000	3606.658
000:00:00:500	000:09:19:300	0.00	0.0000	0.000	0.000	0.000	3606.658
000:00:00:600	000:09:19:200	0.00	0.0000	0.000	0.000	0.000	3606.658

Figure 12. Data Export Feature

In the export spreadsheet file there are two parts, namely the summary of the activity and the record table. The record table is under a summary of activities that contains activity data in detail at sampling times with all parameter fields listed.

7.3. System Test Results

In this test, the method used in the study will be verified using experimental data in the field obtained from a prototype device mounted on the vehicle wheel. To verify the results of the system, the system is tested in the field. Tests are carried out with a scenario running as far as about 150 meters - 300 meters in order to measure the accuracy and consistency of mileage measurements by the system. The following is a data snippet which is then copied by 10 (ten) data recorded in the recording and compared with the speedometer designation recorded on the video.

Table 1. System Accuracy Test Results

Data to	**Actual Speed (km/h)**	**Speed Measured (km/h)**	**Error Absolute Speed**	**Error Relative Speed %**	$X-\underline{X}$	$(X-\underline{X})^2$
1	6.5	6.474	0.026	0.40	0.026	0.00068
2	7.5	7.531	0.031	0.41	0.031	0.00096
3	8.5	8.376	0.124	1,45	0.124	0.01530
4	9.0	9.052	0.052	0.58	0.052	0.00270
5	9.5	9.593	0.093	0.98	0.093	0.00870
6	12.0	12.377	0.377	3.14	0.377	0.14200
7	12.0	12.252	0.252	2.10	0.252	0.06350
8	12.0	12.153	0.152	1.26	0.152	0.02310
9	12.0	12.074	0.074	0.62	0.074	0.00550
10	12.0	12.010	0.010	0.08	0.010	0.00010
Average Error			**0.164**	**1.09**	**Deviasi Standart (σ)**	**0.02625 km/h**

8. Conclusion

Based on the results of research and discussion as disclosed previously, it can be concluded, among others. Infra Red sensor-based prototype system and controlled by a microcontroller using MMC as a data storage designed to provide accurate mileage estimation results with an average error of 1.09% or 98, 91% accuracy. In addition the estimation results are also consistent, which is represented by the system experimental standard deviation value of less than 1 (one) km/h which is equal to 0.02625 km/h. The results of hardware testing indicate that the design is successful through all the test scenarios performed. Personal Dead Reckoning and Zero Velocity Update (ZUPT) techniques on prototype devices designed to produce vehicle speed estimates dynamically over time. GUI applications and firmware are tested by blackbox testing, and indicate that the system is running smoothly. The prototype system has a GUI application that is designed to have a variety of instruments that display data results both numerically and graphically, which can help and simplify the process of monitoring vehicle speed recording activities from time to time.

References

[1] Abdallah Kassem, Rabih Jabr, Ghady Salamouni, Ziad Khairallah Maalouf. *Vehicle Black Box System*. SysCon 2008 – IEEE International Systems Conference, Montreal, Canada, April 7–10, 2008

[2] Atmel. 2016. *ATmega328/P Datasheet Complete*. Available in: *http://www.atmel.com/Images/Atmel-42735-8-bit-AVR-Microcontroller- ATmega328-328P_Datasheet.pdf*

[3] Dheeraj Pawar, Pushpak Poddar. *Car Black Box with Speed Control in Desired Areas for Collision Avoidance.* ETASR - Engineering, Technology & Applied Science Research Vol. 2, No. 5, 2012, 281-284

Journal of Physics: Conference Series **1444** (2020) 012037 doi:10.1088/1742-6596/1444/1/012037

[4] Dwi Purwanti. 2012. *Prototipe Alat Penanda Kecepatan Mobil Di Jalan Raya*. Laporan Penelitian Terapan Unnes. LP2M – Unnes
[5] Hayes, G, Blosser, F "*Motor Vehicle Crashes Claim More than a Million Lives Worldwide*", CDC Injury Center Media Relations, Press Release, April, 2004
[6] Haryono Sukarto .1994.. *Interaksi Faktor-faktor Penyebab Kecelakaan Lalu Lintas di Jalan Tol Sekitar Jakarta*. Tesis S2. UI – Jakarta
[7] Ibrahim, Dogan. 2006. *Microcontroller Based Applied Digital Control*. England : John Wiley & Sons, Ltd. ISBN: 0-470-86335-8
[8] Scott Mueller. *Upgrading And Repairing PCs.* 21st Edition. TomsHardware.com. Que Publishing. ISBN 978-0789750006
[9] Tomer Toledo and Tsippy Lotan. *In-Vehicle Data Recorder for Evaluation of Driving Behavior and Safety*. Transportation Research Record: Journal of the Transportation Research Board, No. 1953, Transportation Research Board of the National Academies, Washington, D.C., 2006, pp. 112–119
[10] (URL: *http: // www.delta-electronic.com* Retrieved June 12th 2009)