Development of Speed-Time Data Logger for Analysis of Motorcyclist Driving Behavior

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Abstract

This paper presents a development of a speed-time data logger for a motorcycle. The speed-time data will be used to create a driving cycle in order to evaluate the amount of exhaust emission and fuel consumption from motorcycles. The device will record the data of time series by using its internal flash memory for every second. Each record contains the data of speed, GPS position, and engine revolution. To ensure that the measurements of speed is close to actual driving of the motorcyclist, the speed and position data detected from GPS module will then be used to compare with that from a developed magnetic induction device. The induction device measures the vehicle speed by using magnetic sensor installed at a fixed brake drum in the rear wheel. The sensor measures the time period of the induced magnetic signal then calculates the speed of the moving motorcycles. And the speed-time data will be added to the memory simultaneously. The data collection will be done by driving a motorcycle with the data logger on the selected road route. After that, the driving cycle will be formed. Traffic conditions and driving behavior of motorcyclist can then be analyzed eventually.

***Keywords**:* Speed-time data logger, Motorcycle Driving Cycle, Magnetic Sensors

1. Introduction

The increasing of number of vehicles in urban area causes many problems of traffic congestion, fuel consumption as well as air and noise pollution. To assess the exhaust emissions and fuel consumption from the vehicles traveling along a public road, a device called "speed-time data logger" is necessary. It will be installed in a target vehicle and the speed-time data from the data logger can then be used to analyze the driving behavior as well as its emission and fuel consumption. [1]

Most devices installed with small vehicles like motorcycles must have some specific program to communicate between the data logger device and computer. This difficulty has been eliminated in this development by using a universal serial port with its standard program. Furthermore, the size of data logger device is designed to be suitable for the selected motorcycle in this study. The developed device is explained in the following sections. In section 2, it briefly explains the operation of whole data logger. In section 3, the communication between sensors and controller is illustrated and explained. The experimental results of developed device are shown in section 4 while the conclusion is given in section 5.

2. Speed-time data logger operation

The hardware of the data logger system is based on PCs, like as the microcontrollers. The microcontroller is used to obtain all sensor data and to manage the data recording and time stamping. Its power supply is a mobile battery which can supply power for more than 3 days. In the experiment, the logger monitors electrical signals from a magnetic sensor to determine the spot speed of the motorcycle by second. Such as date, time, engine speed and position of vehicle are also detected by the device. After that these information will be recorded in the logger's memory and can be removed if a user need. And the data can also be transferred to any remote indicating device or PCs for further analysis and monitoring. The data signals come from three parts; 1) Spot speed of the motorcycle calculated from data obtained from the magnetic sensors equipped on a rear wheel of motorcycle, 2) Engine speed signal from the CDI box, and 3) Velocity and position of motorcycle from the installed GPS device. These data for every second will be stored in a set of database. To display the recording data, a monitor is connected to the device as displayed in Fig.1. The monitor displays the position, the speed, and engine revolution by real time.

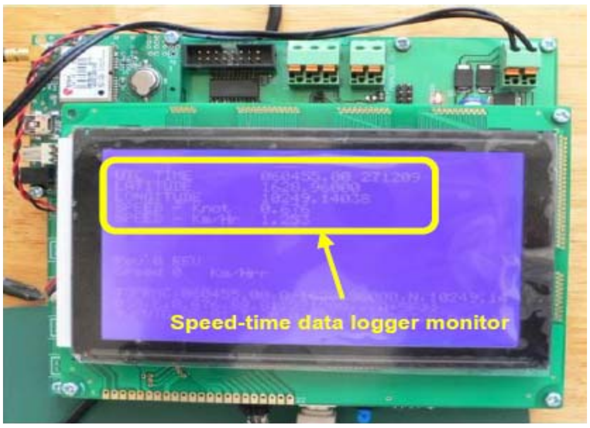

Fig. 1 Monitor of the data logger system

In this work, the data acquisition device is the microcontroller in family of the Philips LPC 210X. It has a 32-bit controller with 16 bit THUMB. Its flash memory capacity is 128 KB and the collected data can be transferred via RS232 interface and Ethernet controller [2]. The external components such as a display monitor, power supply, and analog sensors are also included in order to investigate the measuring signals, to provide energy, and to detect the interesting signals, respectively. A lattice (CPLD) is also used to provide the high resolution of sampling time to stamp all acquired data from the sensors. A main program that used to manage all measuring data is stored in a main memory ROM while the input variables from each channel will be collected in the memory RAM. The system software is designed in order to easily access and inform between a user and a device by using a standard RS232 online programs. It is necessary to consider that the data detection must be performed in the same time as written in the record (Memory flash).

3. Sensors operation and data transfer

The logger device is designed to measure velocity of the motorcycle of interest. It is divided into three parts which are 1) the rear wheel speed sensors, 2) the engine revolution sensors, and 3) The GPS sensor that can detect the motorcycle's velocity and position coordinates movement. The block diagram in Fig.2 details the connection and reception of database.

The direction of receivers and database management for storing data in a main memory are also illustrated.

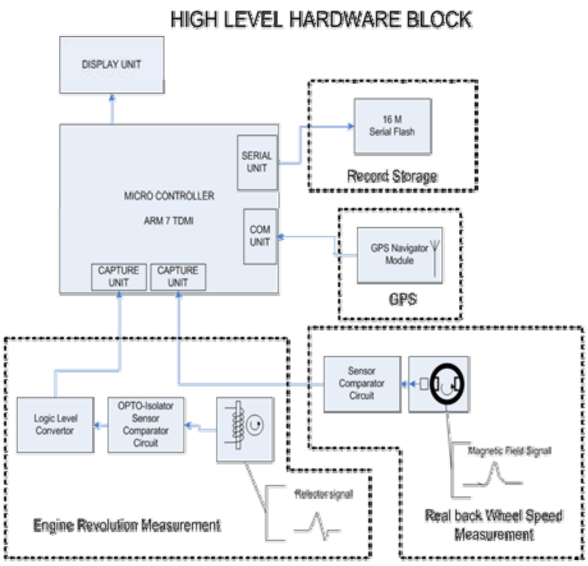

Fig.2 High level block diagram of the speed time data logger.

3.1 The rear wheel speed sensors

To measure the velocity of the motorcycle, a Hall-effect base sensor is installed on the rear wheel of the motorcycle (Fig.3) to detect the wheel rotating speed. A producing pulse can be observed via the magnetic sensor (see Fig.2). These pulses are then converted to voltage signal by using a voltage converter circuit. The microcontroller will convert this voltage signal to be speed time data. The device has been developed to have the capability to log the speed values in term of a per second basis. Fig.3 sensors installed on the rear wheel of the motorcycle.

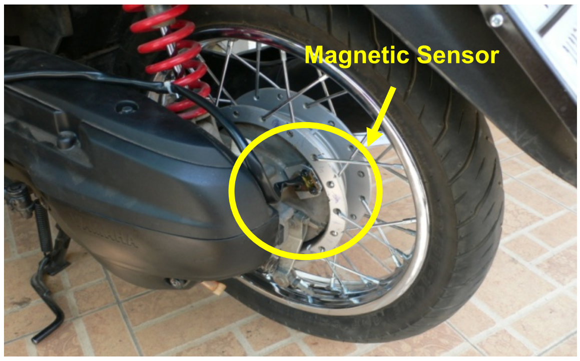

Fig.3 The sensor on the rear wheel of the motorcycle.

The distance between each sensor point on the wheel can be found from eq.(1).

$$360/M = H \qquad (1)$$

Where H is Heading Degrees between both magnetic poles, M is number of the magnetic poles.

From eq. (1), the angle betweens the magnetic poles on the rear wheel of the motorcycle will be obtained. And this angle can be used to calculated distance of the wheel movement as equation shown below

$$D_w = \theta_s \times D_\phi \qquad (2)$$

Where D_w distance of wheel movement is, θ_s is angle betweens the magnetic poles, D_ϕ is Distance per degree.

Due to circumference of wheel equals to $2\pi r$, r is the radius of the motorcycle wheel, the circumference is 111.76 cm in this work. And the distance per degree is 111.76/360 = 0.3104 cm per degree.

From eq. (1) and (2) and there are 2 magnetic pole in this work, the Heading Degrees is 180 degrees and the distance of the wheel movement D_w is 55.879 cm.

3.2 The Engine Revolution Sensors

The engine revolution signal will be measured from extraction pulse data of the Capacitor Discharge Ignition (CDI) in the motorcycle control unit (see Fig. 2 and 4). The microcontroller will read signal from sensors and record the data to the flash memory. Time to add data in the memory (T_f) must be smaller than the maximum of time that used in data connection process (T_r) in the microcontroller. The relationship between T and T_r are shown in eq. (3) and (4).

$$T_f = N_a \, x \, T_p \qquad (3)$$

$$T_f < T_r \qquad (4)$$

Where N_a amount of is received data and T_p is sampling time.

It should be note here that the receiving signal from the Capacitor Discharge Ignition (CDI) has high amplitude spike signal that can disturb the counter process of the microcontroller. To avoid this disturbance, the microcontroller will be programmed to detect the certain period signal only. This is because the time period of the disturbance is quite small compared to the period of CDI signal. The difference is illustrated in Fig 5.

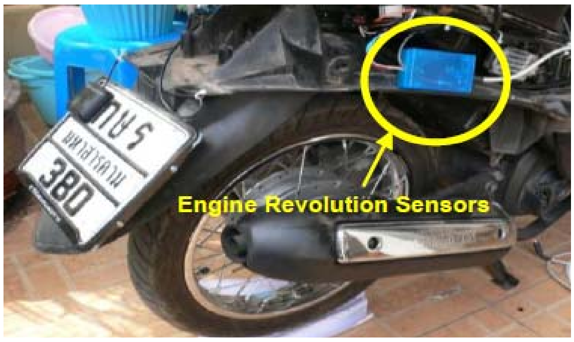

Fig.4 The signal receiving unit from the Capacitor Discharge Ignition (CDI)

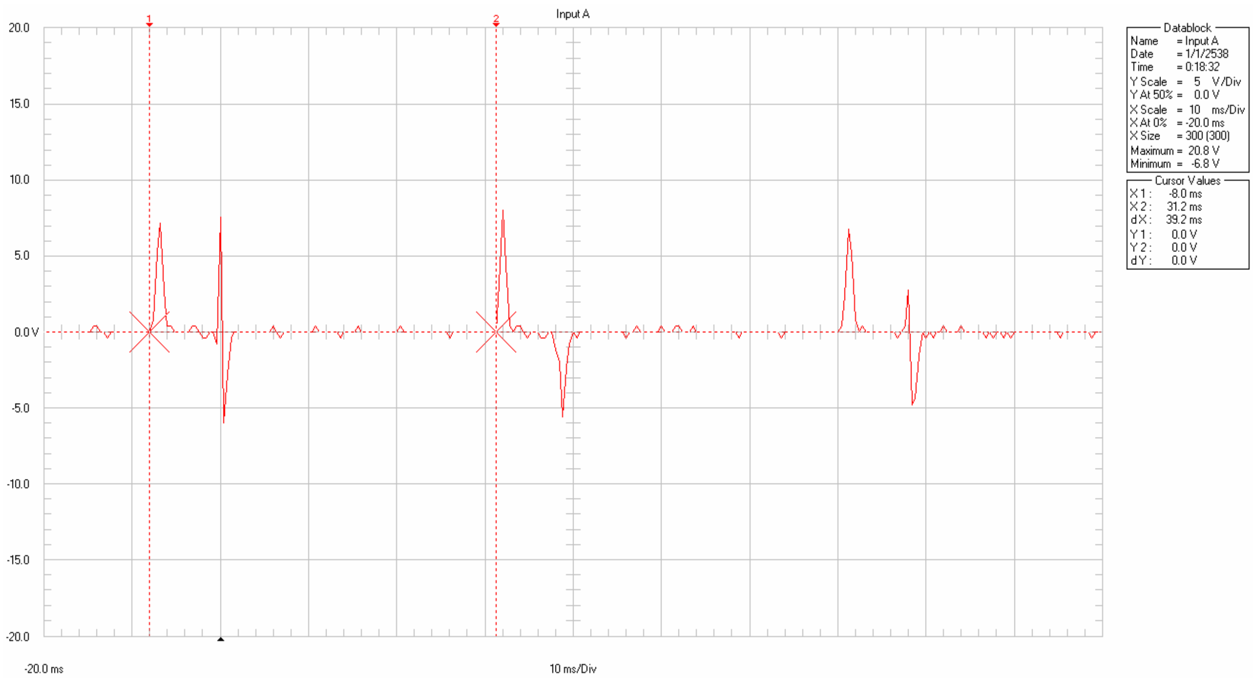

Fig.5 Comparison of time period between the CDI signal and disturbance spike.

3.3 The GPS Sensors

As stated earlier, another source of vehicle velocity data comes from the GPS sensor. It can also measure position of vehicle. In this work, the GPS is used in manner of the Off-line mode for real time recording while the another On-line mode used for real time monitoring [3]. The GPS has been select for verification of the garage made magnetic sensor. It has accuracy of +-2.5 meter and +- 0.1 m/sec for position and velocity measurement respectively.

4. Experimental Results

To test the developed data logger system, the speed data from the magnetic sensor on the rear wheel of the motorcycle and the speed from the speed from the standard GPS were compared with the reference speeds. Results are shown in Table 1. The test has performed on 2 certain distance and expected velocity. Reference speed from stop watch is also shown in the table.

The results show that the information velocity moment of the motorcycle from the magnetic sensor is close to the reference speed. It becomes better when the testing distance is longer. This trend still valid even test on the various speeds. This is because the test has run on cruise speed and the speed from the magnetic sensor came from wheel's revolution. The longer distance provides larger sampling data set. Therefore, the more accurate cruise speed can be calculated from the magnetic device.

Additionally, the developed device is suitable in order to data collection. It is small size, light weight, precise to storage data and increase or decrease size of memory. Architecture of the interface system which related to retrieve the data will used to universal Serial Bus (USB) port to available.

Table 1. A comparison of cruise speed data from the difference sensor.

Cruise Speed	Distance	Start Time	Finish Time	Travel Time	$Speed_{ref.}$	$Speed_{GPS}$	$Speed_{datalogger}$ (Mag.)	$Error_{Mag}$	$Error_{GPS}$
(km/hr)	(m)	(mm:ss.0)	(mm:ss.0)	(s)	(km/h)	(km/h)	(km/h)	(%)	(%)
30	500	00:00.0	01:00.07	60.07	29.97	30.60	30.70	2.45	2.12
30	500	00:00.0	00:56.61	56.61	31.80	31.02	31.89	0.29	-2.44
30	1000	00:00.0	01:53.85	113.85	31.62	31.53	31.86	0.76	-0.29
30	1000	00:00.0	01:58.44	118.44	30.40	30.02	30.57	0.58	-1.23
50	500	00:00.0	00:35.05	35.05	51.36	50.17	50.39	-1.9	-2.31
50	500	00:00.0	00:35.59	35.59	50.58	51.64	51.33	1.49	2.10
50	1000	00:00.0	01:11.55	71.55	50.31	49.61	50.48	0.33	-1.40
50	1000	00:00.0	01:11.82	71.82	50.13	50.13	50.47	0.69	0.01

Consequently, the developed speed time data logger device has been used to collect the speed time data on real road for 1 month. And the result of driving cycle that generated from the speed time data by using some specific algorithm [4] is shown in Fig. 6.

6. Acknowledgement

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7. References

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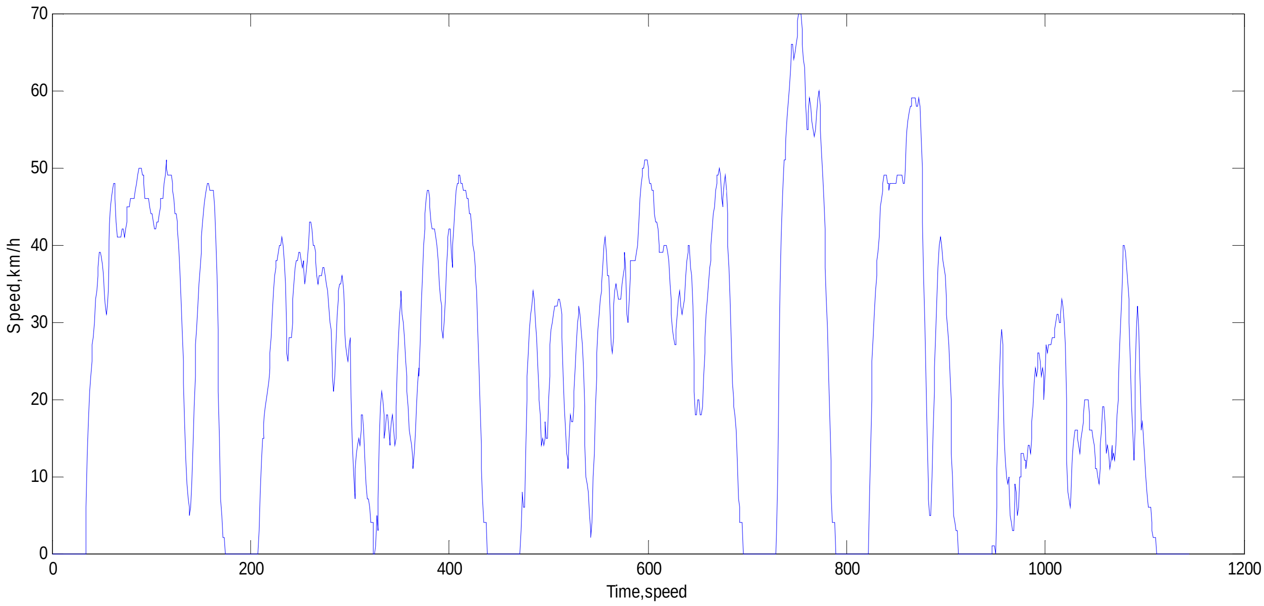

V_{max} =70 km/h; Acc_{max} = 3.61 m/s ^{2}; Dec_{max} = -2.22 m/s ^{2}; length 1145 s; distance = 7.647 km

Fig 6. Khon Kaen motocycle driving cycle

5. Conclusion

This paper deals with the design of a speed-time data logger system for motorcycles. Its accuracy is +-2.45 percent when compared with reference speed. The accuracy will be better if the experiment performs on the longer distance. Additionally, due that the developed device is compact, its battery provides long life for data collection, and it is convenient to transfer data to laptop PC, the developed speed time data logger has been used to collect the motorcycle speed data on real road in Khon Kaen City. And the driving cycle can then be generated eventually.