Development of data logger for motorcycles

Masashi Matsuo　Takeshi Morioka　Hitoshi Watanabe

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要旨

モータサイクル用のデータロガーには、レースやクローズドコースでの走行データの計測を行うためのものがある[1]。これらのデータロガーでは、車載するときに、走行に影響がないように小型、軽量、最適化がされている。そのため、ひずみ式のセンサ類を計測するためのアンプやフィルタ類が搭載されていない物がほとんどである。また、アンプやフィルタが内蔵されているデータロガーは、大型のものが多く、耐久性や防水、防塵性といった観点で二輪車の走行時には、使用できないものがほとんどである。モータサイクルの車体開発では、車体の強度や運動特性を理解するため、ひずみや加速度の計測を行っている[2][3]。また、開発の効率化や走行時の現象の理解を深めるため、計測チャンネルをより多くすることと位置情報の取得が求められている。

そこで、モータサイクルの車体開発で使用するために、データロガーの開発を行った。本開発では、アンプとフィルタを内蔵することで、各種センサ情報を計測できるようにした。また、複数のデータロガーを同期させることで、チャンネル数を増やせるようにした。さらに、データロガーのケース内に樹脂を充填することで、耐久性や防水、防塵性を向上することができた。結果、モータサイクルの車体開発に最適なデータロガーが開発された。

Abstract

The data loggers that are used on motorcycles are intended to measure the running data during races and when driving on closed courses [1]. These data loggers are small in size, lightweight, and optimized for mounting on motorcycles so that they do not affect the vehicle dynamics. Consequently, almost all of these data loggers are not equipped with the amplifiers and filters necessary for taking measurements from strain sensors. Most of the data loggers that have amplifiers and filters built into them are large in size and cannot be used on a motorcycle while it is being driven because of their poor durability, poor water resistance, and poor dust resistance. However, it is necessary to carry out strain and acceleration measurements when developing a new motorcycle body so that the body strength and motion characteristics can be understood [2][3]. Furthermore, the ability to increase the number of measurement channels and acquire position information is also being demanded to improve the efficiency of development and deepen our understanding of the phenomena that occur during driving.

Consequently, a new data logger was developed for use during the development of new motorcycle bodies. In the data logger that was developed, both amplifiers and filters are built in and it is able to measure the information coming from each of the various sensors. The number of channels was also increased by synchronizing multiple data loggers. In addition, the durability, water resistance, and dust resistance of the data logger were all improved by injecting resin inside the data logger case. As a result, the most suitable data logger for use during the development of new motorcycle bodies was developed.

1 INTRODUCTION

Running tests are carried out when a new motorcycle is being developed to evaluate the strength and performance of the motorcycle's body. The measurement data that is collected is mostly analog signals (acceleration, strain, and voltage, etc.) and digital signals (engine speed and tire speed, etc.). In many cases, GPS data is also collected at the same time as these measurements in order to obtain position data. This is done for the purpose of reproducing the tests and understanding the test conditions.

When these running tests are carried out in the rain or on rough roads (Figure 1), there are cases where vibrations and water infiltration cause the components on the substrate to peel off and the data loggers to malfunction (Figure 2). If the data loggers malfunction, it becomes necessary to suspend or postpone the running tests. This is why it is so desirable to limit these malfunctions as much as possible and have data loggers that can be used for long periods of time. In comparison to an automobile, there are not many places where equipment can be mounted on a motorcycle, so it is also desirable for the data loggers to be small in size.

There is great demand to make the motorcycle body development process even more efficient and the number of different measurement items is also growing more and more diverse. This means that, depending on the running test that is being carried out, it is also desirable to expand the number of measurement channels so that multiple items can be evaluated at the same time.

In recent years it has become necessary to output the physical values that are calculated from the various sensor values. These sensor values include the internal information from a controller, such as the engine control unit (ECU), and also the values from GPS sensors that use inertial sensors to correct the position data. In this case it is also desirable to measure the CAN communication information [4].

Consequently, a data logger for use on motorcycles was developed at our company in order to satisfy these various demands.

2 REQUIRED ITEMS

The following were determined to be the required items for a motorcycle-mounted data logger that would make it possible to efficiently collect data during the development of a new motorcycle body.

Figure 1: Rough Road Running Test

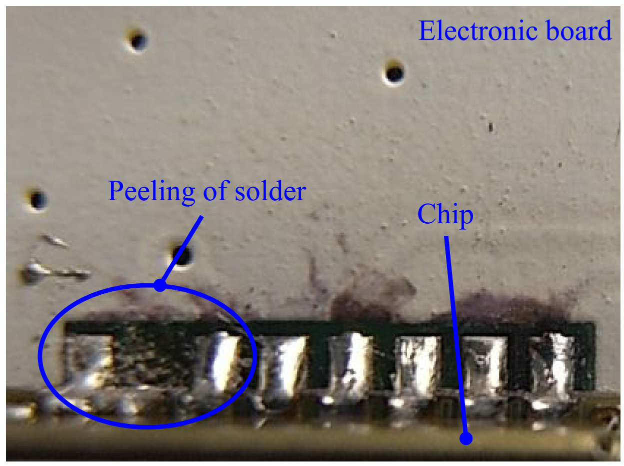
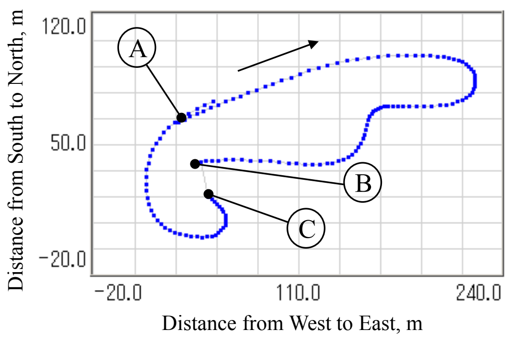


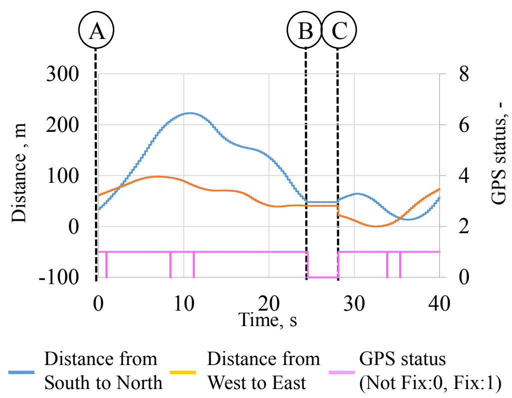
Figure 2: Component Damage Caused by Vibrations

2-1. GPS position data acquisition function

GPS data to acquire position data are measured in order to reproduce the tests and to understand the test conditions. Figure 3 and 4 show example GPS data which were measured at different mount position of the GPS antenna. In the Figure 3 the GPS antenna was installed in the front cowl. In the Figure 4, the GPS antenna was installed on the front fender. In the Figure 3 and 4, A, B and C show the measuring points. The GPS status data in the Figure 3 were 0 between B and C. When the GPS status data were 0, the GPS data weren't acquired. On the other hand, the all GPS status data in the Figure 4 were 1. When the GPS status data were 1, the GPS data were acquired. In this way, GPS data cannot be acquired due to mount position of antennas. Therefore it is necessary to keep flexibility at the mount position of antennas in order to receive GPS data.

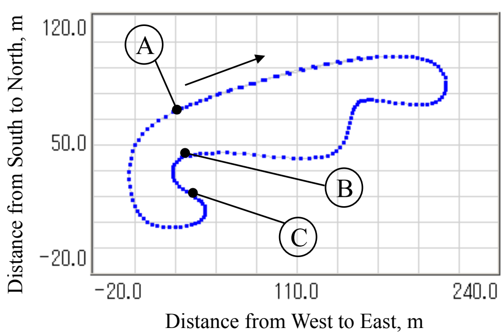


(a) GPS Locus Data

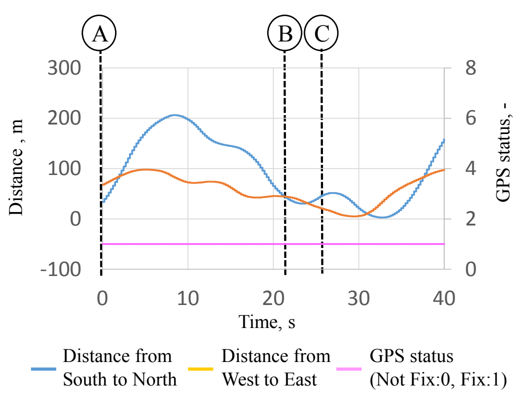


(b) Time History Data

Figure 3: GPS Data (GPS Antenna in the Front Cowl)



(a) GPS Locus Data



(b) Time History Data

Figure 4: GPS Data (GPS Antenna on the Front Fender)

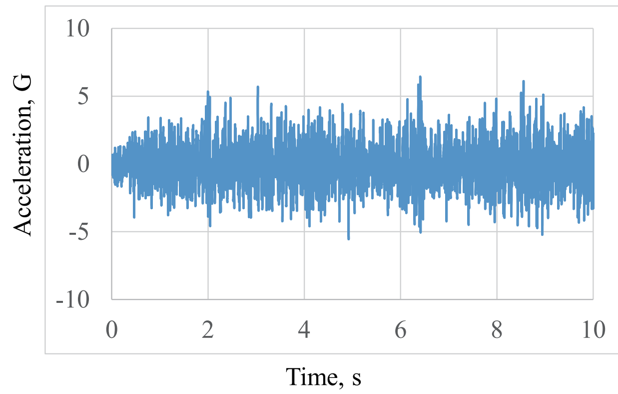


Figure 5: Acceleration under Seat

2-2. Strain and acceleration measurement function

Strain and acceleration data is measured in order to understand the body strength and motion characteristics. Some amplifiers and signal filters for strain and acceleration measurements should be equipped.

2-3. Small in size and lightweight

It is desirable for the data logger to be small in size because there are not many places where equipment can be mounted on a motorcycle. In addition, it is desirable to be lightweight because it does not affect the vehicle dynamics.

2-4. Improved dust resistance, water resistance, and vibration resistance

It is desirable for the data logger to have water resistance and dust resistance because the running tests are also carried out in a rainy day. Figure 5 shows example acceleration under seat in the rough road running test. It is desirable for the data logger to have vibration resistance to limit malfunction in the rough road running test.

2-5. Expanded number of measurement channels

It is desirable for the data logger to have a lot of measurement channels because there is great demand to make the running test even more efficient.

2-6. CAN communication function

It is desirable for the data logger to measure the body motion and internal information of ECU simultaneously, for the analysis of ECU operations.

2-7. Fast acquisition of measured data

There is demand to improve the efficiency of the running test.

3 METHODS OF REALIZING THE REQUIRED ITEMS

This new data logger was developed using the following methods to help ensure that all the required items were realized.

3-1. Connection to GPS receivers

The data logger was designed to be able to connect to a RS-232C-compliant, commercially-available GPS receiver via its serial port. The data logger and GPS receiver are separate components that can be connected through a wiring harness so that it is possible to mount the GPS receiver in a different location than where the data logger is mounted. This in turn improved the freedom to determine where to mount the GPS antenna and so the antenna could be mounted in a location with good reception sensitivity.
The format of the information output by GPS receivers is often the same, but it can be different depending on the model of receiver. This means that the digits of the output values and communication speed are different. Therefore, the data logger was designed to be able to automatically detect these differences internally and measure them depending on the model of GPS receiver that it is connected to. As a result, the number of possible GPS receivers that this data logger can be connected to was increased.

3-2. Integration of the amplifier and low-pass filter

An amplifier and low-pass filter are both equipped on the main body of the data logger. This enables the data logger to be connected directly to strain sensors and acceleration sensors and to take measurements from them. An integrated design such as this also means that fewer wiring harnesses can be used to connect the data logger and sensors in comparison to data loggers that have separate amplifiers and filters.
On the other hand, it is necessary to set the appropriate values for the gain and cutoff frequency of the amplifier and low-pass filter depending on the measurement conditions. Therefore, the data logger was designed so that these values could be set afterwards and computer software was also developed that allows these values to be set as needed. The data logger is connected to the computer via USB ports and then the values can be set.

3-3. Injection of resin

Waterproof connectors were used for the connectors and resin was injected between the main body of the data logger and the case (Figure 6). Encasing the main body of the data logger in resin helps prevent the components from peeling off due to vibration and also helps prevent water infiltration to a certain extent.
There are times when gasoline and engine oil may be spilled on the test vehicle during maintenance, so an epoxy resin was used that is strongly resistant to gasoline and various types of oil.

3-4. Synchronized measurement

The data logger was designed so that when multiple data loggers are used together, the measurement timing of each of the data loggers could be synchronized. Figure 7 shows how multiple data loggers are connected to each other. The data loggers can be set to be the “master” or “slave” using the computer software that was described previously. The data logger that is set to be the “master” acquires the measurement data at the set sampling frequency and then outputs the timing signal acquired from the data to external devices via the OUT port. On the other hand, the data loggers that are set to be the “slaves” have this timing signal input through their IN ports. This determines the timing for acquiring the measurement data and then they in turn also output the timing signal acquired from the data to external devices via their OUT ports.
This method allows for several data loggers that used the measurement data to be connected. This means that in the case where you wish to combine all the measurement data into a single data set, a computer and the software

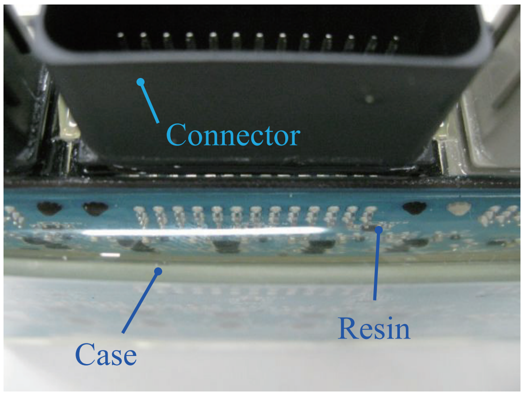


Figure 6: Injection of Resin

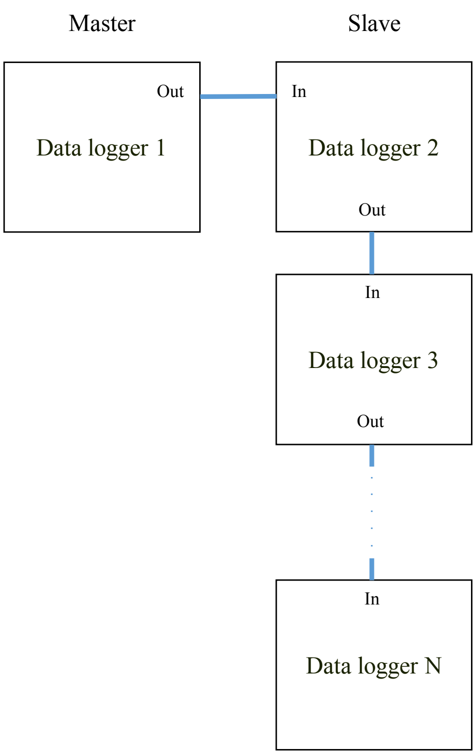


Figure 7: Synchronization of Data Loggers

described above can be used after the testing is completed to collect and combine all the measurement data together.

3-5. CAN communication

The data logger was equipped with a CAN communication port so that it can be connected to CAN communication devices. In the case where CAN communication is carried out, it is necessary to connect the end of the communication cable to a terminating resistor (120 Ω) in order to prevent reflection of the signal. However, there are also cases where having a terminating resistor within the data logger is not necessary depending on how everything is connected. This is due to the fact that when CAN communication is used, it is possible to have branching and connections to multiple CAN communication devices. The data logger was designed so that the terminating resistors that are necessary for the CAN connections can be selected as needed depending on the connection method employed for the wiring harness. Figure 8 shows a portion of a circuit diagram for a CAN signal. The line marked "CAN1-L" is the LOW line for CAN communication and the line marked "CAN1-H" is the HIGH line. In this case, if "CAN1-T" is connected to "CAN1-L", a terminating resistor can be inserted.

3-6. Reducing the time necessary to acquire measurement data

The data logger was also designed so that the measurement data can be acquired using a computer via USB communication. The storage format for the measurement data was set to be binary, so in comparison to the text format, the volume is smaller and it is easier to transfer. However, data that is in this binary format cannot be read by spreadsheet software, such as Excel, so additional software that can read this binary data and convert it into text format was prepared separately.
Furthermore, the data logger was also designed so that the measurement data could be stored on memory cards and this makes it very easy to move the data around by simply inserting and removing these cards. In the case where the measurement data is being checked and the test is being repeated continuously, the ability to reduce the amount of time needed to acquire the measurement data should lead to more efficient testing.

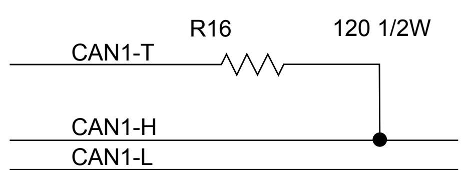


Figure 8: Terminal Connection of CAN Communication

4 SPECIFICATIONS OF DATA LOGGER

Figure 9 shows the external appearance of the data logger that was developed. The following lists the specifications of this data logger.

- Size: 97×33×178 mm (not including connectors)
- Mass: 700 g
- Sampling frequency: 1- 20 kHz
- Analog input: 12 channels
- Digital input: 6 channels (including switch input)
- Serial communication: 2 channels
- CAN communication: 2 channels
- Low-pass cutoff frequency: 10-10kHz
- Power supply: DC 7-18V, max 1.5A
- Water-resistance: JIS D 0203 R2 (not including USB connector and memory card slot)
- Vibration-resistance: confirmed by running test in house

Figure 9: External Appearance of Data Logger

5 EXAMPLES OF DATA LOGGER USAGE

Figure 10 shows an example of how the data logger is connected during a running test. During these tests the data logger is either placed in the carrier box, the storage space under the seat (Figure 11), or is anchored in place as is on top of the seat. The power supply for the data logger comes from either the battery mounted on the vehicle or a separately mounted battery. The strain gages and acceleration sensors are placed in the locations where measurements are desired. The GPS receiver is placed in a location with good reception sensitivity, where neither the rider nor the vehicle itself will interfere with the reception. The operational switches for the data logger are placed under the handle bars or some other location where the rider can operate them easily. These operational switches allow the rider to begin and end the measurements, adjust the balance of the strain gages, and perform marking while riding the vehicle. A computer can be connected to the data logger via USB and the dedicated software can be used to set the measurement conditions and also to monitor the measurement values. It is not necessary to mount the computer on the vehicle when taking these measurements.

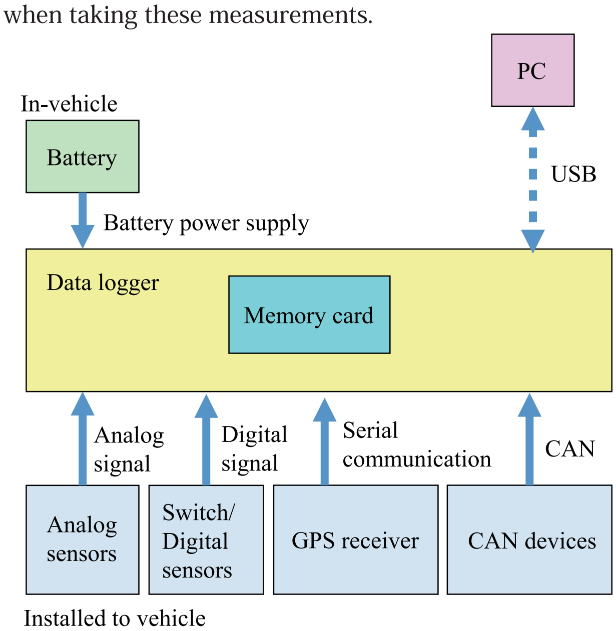


Figure 10: Example of Data Logger Connections

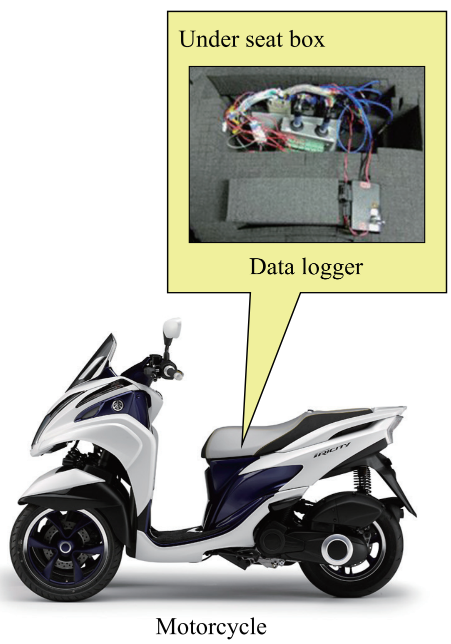


Figure 11: Example of Data Logger Mounting

6 EXAMPLES OF MEASUREMENT DATA

Figure 12 shows an example of the GPS data that was measured. The GPS data acquired during the running test includes the GPS trajectory and also a color-coded record of the vehicle's velocity. This measurement data clearly shows where the vehicle was running and at what speed. It can be used to confirm the running conditions after the test is completed. This data is also very useful in the case where it is necessary to reproduce this running test.

In recent years it has also become much easier to record video at the same time as the measurements are being taken thanks to the development of video cameras that can be mounted on the vehicle. Figure 13 shows how the combination of the measurement data and the video footage allows people other than the rider who performed the test to easily understand the driving conditions during the test. This can be used as a communication tool between the test rider and the engineers since there are some tests that can only be performed and evaluated by a skilled rider depending on the test conditions.

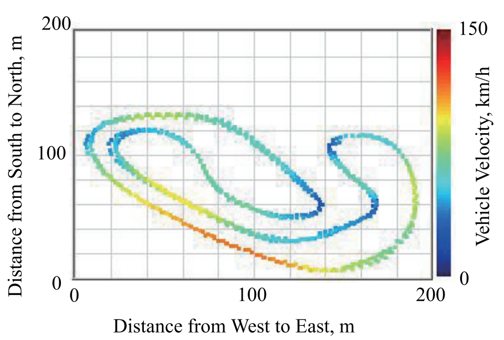


Figure 12: GPS Data

Figure 13: Driving Video and Measurement Data

7 FUTURE CHALLENGES

The new data logger that was developed has been used for the in-house development of new motorcycle bodies. The performance of the tests themselves and the data analysis that is carried out after the measurement data is acquired have all become more efficient as a result of using a common data logger for these running tests within the company.

On the other hand, there have also been cases where it was difficult to use this new data logger during the development of smaller model motorcycles and competition models due to the size and weight of the data logger. For example, there were cases where sufficient space to mount the data logger on the vehicle could not be ensured and other cases where the presence of the data logger had an effect on the movement of the vehicle. Consequently, there are demands to further reduce the size and weight, as well as to improve the mounting capability of the data logger.

There are also some portions of the data logger that have poor vibration resistance and water resistance due to the USB connector and ability to insert and remove memory cards. Improvements that will address these issues are also required.

Not only is there a need to improve the performance of the data logger's hardware, there is also a need to make the software that is used to adjust the settings easier to use. In addition, there is a strong desire to develop new software tools that will make the testing work even more efficient, such as analysis tools and tools that will automatically generate test and data reports.

8 CONCLUSION

A GPS data logger for use on motorcycles was developed. The required items that would make it possible to efficiently collect data during the development of a new motorcycle body were determined and then a data logger was developed that could satisfy all of those requirements. As a result, the data logger that was developed is being used during the in-house development of new motorcycle bodies.

In the future, a new version of this data logger will be developed that is even smaller in size, lighter in weight, and is easier to mount on a wide variety of different models of motorcycles. In addition, the performance of the data logger's hardware will be improved and the software that is used to adjust the settings will be made easier to use. New software tools will also be developed, such as analysis tools and tools that will automatically generate test and data reports.

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■著者

松尾 匡史
Masashi Matsuo
技術本部
研究開発統括部
基盤技術研究部

森岡 剛
Takeshi Morioka
PF車両ユニット
PF車両開発統括部
実験企画部

渡辺 仁
Hitoshi Watanabe
技術本部
研究開発統括部
先進技術研究部