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Testing Environment for Active Safety Systems

Shivakumar K[1], Shishir Y S[2], Neeta B Malvi[3]

[1]*Dept. of ECE, RV College of Engineering, Bangalore, India*
[2]*Dept. of ECE, RV College of Engineering, Bangalore, India*
[3]*Assistant Professor, Dept. of ECE, RV College of Engineering, Bangalore, India*

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Abstract - Since the era of industrial revolution automobiles and in particular motorcycles, have been a popular and convenient way of transport. Motorcycles had an important role in the motorized military of World War II. Motorcycling is also seen as an adventurous sport. However, the motorcycling has its own safety risks and hazards which can lead to destruction of property and life, if handled improperly. The riding conditions like steep hills, aquaplaning due wet surfaces, sharp curves can lead to motorcycle accidents. The number of accidents that occur in India is quite worrisome, about 3500 people in India alone succumb to death due to motorcycle accidents.

These reasons lead to development of electronic safety systems. The incorporation of electronics in motorcycles began as early as 1980, today there are a wider range of electronic safety systems such as antilock braking system, motorcycle stability control, hill hold control, motorcycle traction control. The antilock braking system also known as ABS, is quickly gaining popularity among the motorcycle manufacturers as well riders. As the production of the motorcycle increases the time to market of the antilock braking systems has to be reduced. The time taken for testing of the antilock braking system plays a major role in the time to market of the antilock braking system, by reducing the time taken for testing, antilock braking systems can be produced more quickly.

***Key Words*: Antilock braking system, acceleration signals, momentum signals, virtual bike**

1. INTRODUCTION

The antilock braking system is a very useful mechanism when the motorcycle is being rode on a wet surface. The wet surface has a thin film of the water which leads to a phenomenon of aquaplaning. The aquaplaning reduces the coefficient of friction, reduced coefficient of friction leads to wheel slip and wheel locking which results in the loss of vehicle control if the rider panic brakes, i.e. the braking force is excess to what is required.

Antilock braking systems work by controlling the amount of the brake force applied on the wheel by the rider based on the wheel speed and vehicle speed inputs. In order to test the antilock braking system, the gyroscope signals such as acceleration signals and momentum signals are required. A model can be developed which reduces the time to market of the motorcycle. These signals act like an offset for the signals from virtual bike and provide fault free system. Once the fault free system is obtained, various functionality checks can be made. This model greatly increases the efficiency as it reduces the dependency on the virtual bike.

2. DEVELOPMENT OF THE SYSTEM

The model to be developed can be categorized as the one that has to be incorporated onto the virtual bike, the other that should be able to run on the user personal computer

2.1 Simulation of gyroscope

The gyroscope model takes the input signals such as roll angle, pitch angle yaw angle and vehicle speed, this model generates acceleration and momentum signals as output. The angular signals should be first converted to units of radians and the vehicle speed should be converted into units of meters per second. The model has a provision for the rotation of the signal axes as per the motorcycle. The model also simulates the noise that is present in the actual gyroscope signals.

The algorithm for derivation of the acceleration signals is as follows:

- Read the angular and velocity signals.
- Resolve the velocity vector into x-y, x-z and y-z planes
- Differentiate the resolved vectors with respect to time interval "dt" to arrive at the acceleration signals
- Calculate the angular signal rates by differentiating with respect to time interval "dt".
- Multiply the angular rates with resolved vectors to arrive at the momentum signals.

The algorithm can be implemented using either C programming language or C++ programming language. However, C++ is preferred due to modularity which is helpful in designing the generation of acceleration and momentum signals separately.

The two point derivatives used in differentiation leads to derivative noise. This derivative noise can lead to large intolerances in the output signals. The derivative noise can be reduced using a kalman filter. It is found that the kalman filter efficiently reduced the noise and the error is substantially reduced.

The figure 1. shows the flow chart for the proposed model.

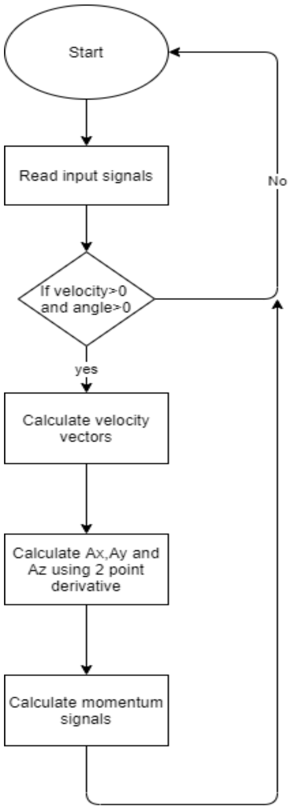

Fig 1. Flow chart for gyroscope simulation.

2.2 Methodology for testing environment

The requirements for the test bench are obtained from the database. The database consists of Tx and Rx messages that needs to be controlled. These messages are of 8 bytes.

And they are obtained from the real time vehicle traces. Vehicle traces are obtained from CANalyzer configuration. Each messages have unique checksum value that needs to be calculated based on the algorithm of J1850 protocol. These checksum takes into account 6 bytes of constant data and 1 byte of alive counter, which keeps incrementing for each cycle. CAPL (CAN access programming language) is used for controlling vehicular network data. And required features are added to the vector panel to design user friendly GUI. The figure 2 gives the test bench for ABS.

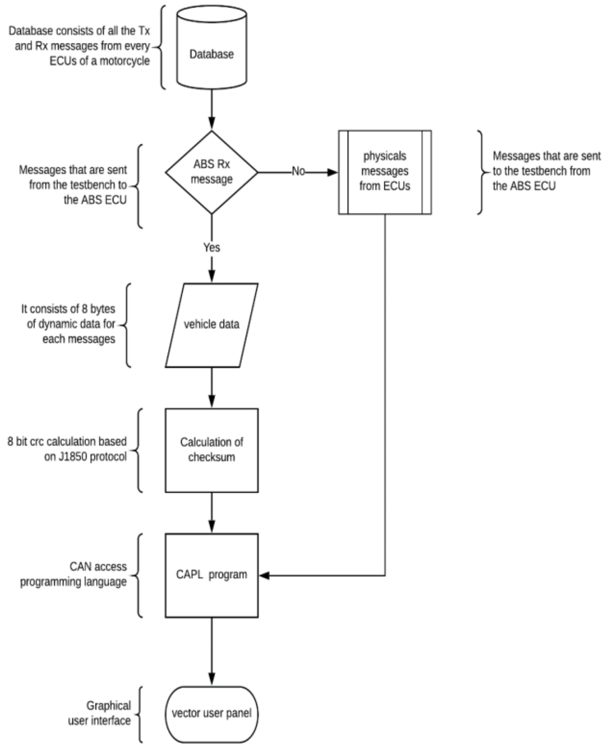

Figure 2. Flow chart of ABS test bench

3. RESULTS AND DISCUSSIONS

The model was developed for simulating the gyroscope signals, the accuracy of ±10% was achieved for acceleration and momentum signals.

The panel was designed using Vector CANalyzer. CAPL scripting was done and they were assigned to their respective system variables. These system variables were assigned to the respective tool in the vector panel.

3.1 Simulated accelerated and momentum signals

The table 1. shows the obtained mean results for acceleration and momentum signals.

It is observed that the error percentage for Ω_z is relatively higher as compared to other momentum signals, this is because the model does not account for the road vibrations which are mainly in the x-axis. The further development of the model can be done to incorporate road vibrations.

Table 1

Error percentage for obtained signals.

Signals	Error percentage
A_x	6.72%

A_y	5.76%
A_z	-6.78%
Ω_x	6.33%
Ω_y	5.12%
Ω_z	-8.97%

3.2 Features of the test bench

Figure 3. illustrates the features of the test bench.

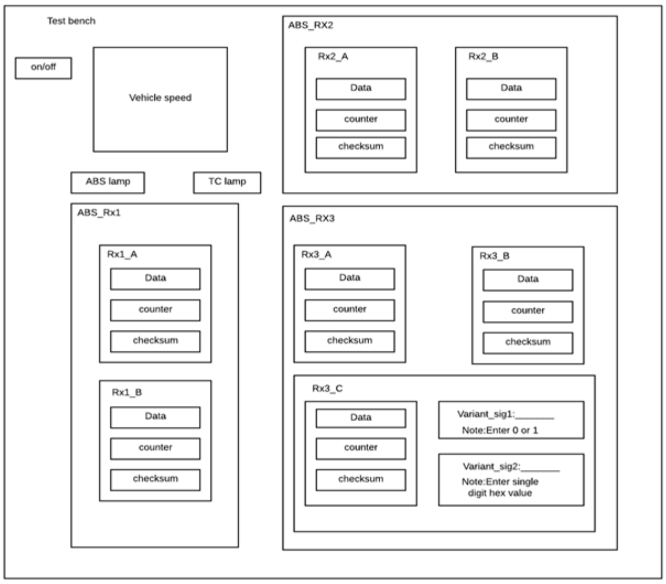

Fig 3. Test bench for ABS

1. On/Off: This switch when pressed starts or stops the dynamic vehicle traces for analysis.
2. Vehicle speed: This speedometer indicates the speed of the wheel at real rime.
3. ABS lamp: This lamp is on when ABS functionality is active.
4. TC lamp: This lamp is on when traction control functionality is active.
5. ABS Rx Messages: These are the messages which are sent to ABS ECU to obtain fault free system.
6. Data: This switch when pressed stops that particular Rx message in the traces for analysis.
7. Counter: This switch when pressed stops the counter byte (7th byte) of that particular Rx message in the traces for analysis.
   (Note: Each Rx message consists of 8 bytes)
8. Checksum: This switch when pressed stops the checksum byte (8th byte) of that particular Rx message in the traces for analysis.
9. Variant signal 1: This signal is a variant which means it has different modes of operation. The mode required can be chosen by entering either 0 or 1 as each bit is assigned to their respective operations.
10. Variant signal 2: This signal is a variant which means it has different modes of operation. The mode required can be chosen by entering single digit hex value as each value is assigned to their respective operations. When the on switch is pressed, the CAN traces are sent to ABS ECU which acts an offset to Virtual bikes and hence obtain a fault free system for analysis.

4. CONCLUSIONS

The model generated required output signals with an average error percentage of 6.74%, Ω_z has the largest deviation from the mean error percentage of the signals. This is because this model does not account for road vibrations. The model can be further developed to incorporate the road and vehicle vibrations for more accurate results.

The test bench is designed to one specific OEM and the fault free system is obtained.

Dependency on virtual bike is greatly reduced. Although most of the functionality checks can be done using this test bench, some critical functionality checks needs to be done using virtual bikes. So, this provides an area for improvement and can be extended to different OEMS with different features.

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