Design of advanced vehicle dynamics evaluation system

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Abstract– ***Vehicle dynamics is specialized on studying the movements of vehicles, automobiles, trucks, buses and special purpose vehicles on a road surface, also the performance of the vehicles. It plays an important role in vehicle design and improvement. Understanding vehicle dynamics can be accomplished at two levels, analytical and experimental level. For experimental level, this paper targets to present a mechanism that determines the motion parameters synchronized during accelerating, braking, ride forces and turning radius, which enables us to detect vehicle performance and stability [1].***

I. Introduction

Vehicle Dynamics is the engineering subject that is interested in studying movements of vehicles, such as acceleration, braking and turning, which is a response to vehicle ride [1].
Vehicle dynamics measurements are important for vehicle design and development. The later research of vehicle dynamics concentrated on various working conditions and service performances under external excitation [2]. currently, the vehicle ride comfort and handing stability research have been widely inspected. The handling dynamics deals with the lateral dynamics or transverse dynamics of the vehicle, which mainly refer to vehicle handling stability, vehicle sideslip caused by tire lateral force, yawing and roll motion. The vehicle driving dynamics is divided into longitudinal dynamics and vertical dynamics, which includes driving, braking and ride comfort. The problem of driving slip and braking slip are solved by the study of vehicle longitudinal tire force, which can also improve driving and braking efficiency. The ride comfort focuses on vehicle vibration and pitch movement caused by vertical tire force.

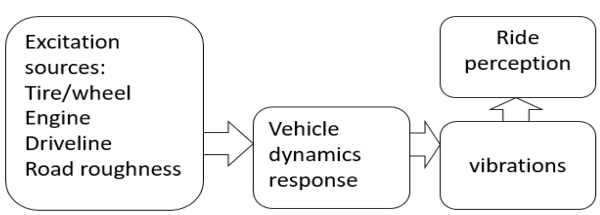

Figure 1.1. vehicle ride(visual vibration)

In addition, the field of vehicle dynamics research also involves the longitudinal force of tire when vehicles are speeding up or braking and vehicle vibration caused by the working engine.
So that many vehicle dynamics measurements are carried out to evaluate vehicle handling which describes the vehicle responds to the driver.

From this point of view, we design a system that measure vehicle dynamics using various sensors, taking in account the disadvantages of the other companies that do the same thing with their own systems, but these systems are expensive, have low durability and precision and low efficiency.so we design a system with the following advantages:
1-low budget system even though it provides high efficiency.
2- high precision optical and mechanical measuring sensors.
3- customized adapter parts ensuring a reliable operation.

II.LITRATURE REVIEW

KIDAQ data acquisition system; it is produced by KISTLER company.it is used for performing vehicle dynamics testing such as braking distance measurements, steady state circular course, driving or double lane change tests. Kistler delivers dependable complete systems for high precision measurements for longitudinal and transverse dynamics, underpinned by their correvit technology. it is used to measure more than 20 analog and digital signal types received from various sensors such as:
1-MSW sensor: used to measure the steering moment, steering angle and steering speed.
2-one axis optical sensor.
3 two axes optical sensor.
4-microwave sensor.
5-optical laser height sensor.
6-wheel vector sensor.
7-wheel torque transducers.
And many other sensors as shown in the following figure:

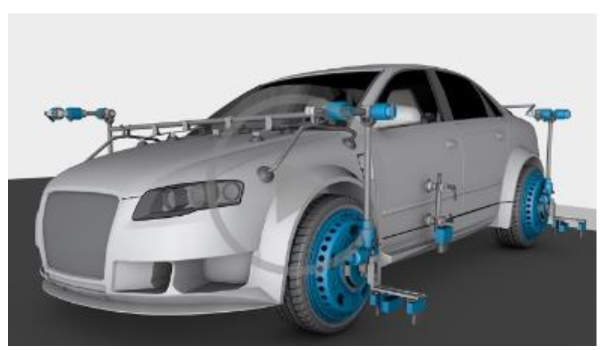

Figure 3.1.the tested vehicle

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From this system we deduce our idea for our system but with other advanced sensors.

III-SYSTEM DESCRIBTION

A- In our test, we use a compactRio for data acquisition as it provides a high performance capability, sensors specific conditioned I/O, and a closely integrated software tool chain that make them ideal for processing, industrial control and monitoring.

Figure 2.1. CompactRio

B- We use LABVIEW software for applying compactRIO code, LabVIEW simulation environment provides an easy solution for this problem. The Control Design and Simulation Module of LABVIEW can be used with the data acquisition, GPIB, CAN, and FPGA (field-programmable gate array) hardware platforms of National Instruments.

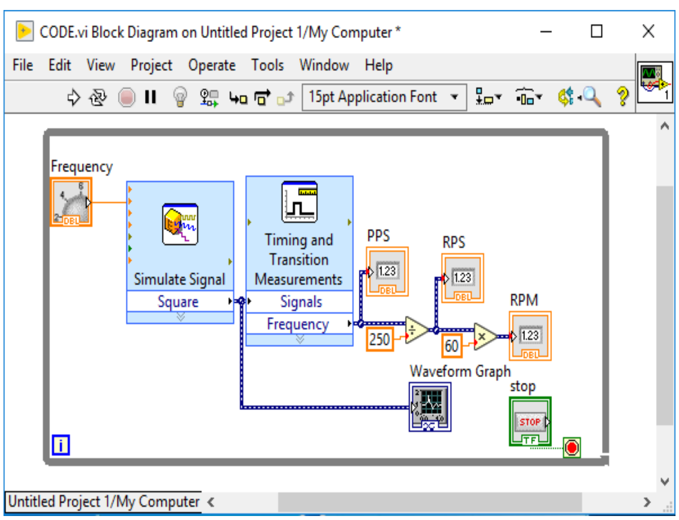


Figure 2.2 block diagram.

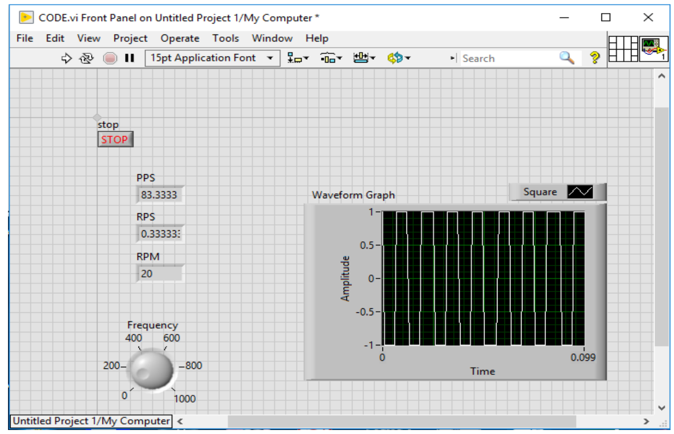


Figure 2.3 Front panel.

C- We use sensors fastened on the vehicle to measure various parameters to ensure and confirm our readings as the sensors converts a physical phenomenon into a measurable analogue voltage (or sometimes a digital signal) converted into a human readable display or transmitted for reading and further processing.

(1-) Fifth wheel:

Figure 2.4 Fifth wheel

Peiseler GmbH is a well-known manufacturer of fifth wheels equipped with an optoelectronic system and a magnetic pulse generator. They deliver comprehensive measuring systems designed for testing of the following car motion parameters:

- Travelling speed.
- Acceleration.
- Braking distance.
- Braking time.
- Length of the distance travelled.
- Testing time.
- Fuel consumption.
- Wheel spin.

(2-) Speed Sensor:

Figure 2.5 speed sensor

The MT pulse generator was specially developed for measuring the wheel speed of vehicles. It delivers 25 – 5000 pulses/revolution (others on request) and can be replaced uncomplicated. The calculation of wheel speed, distance, acceleration, and vehicle speed is possible. Applications are e.g. speed measurements, wheel slip measurements and ABS / ESP tests.

(3-) Turning radius measuring mechanism:

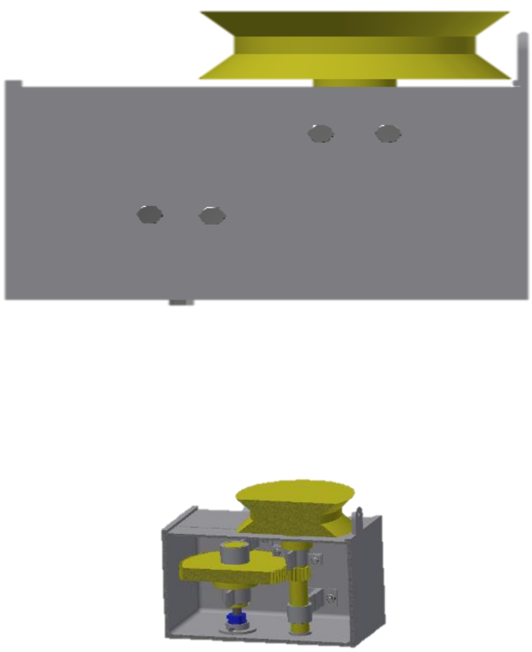
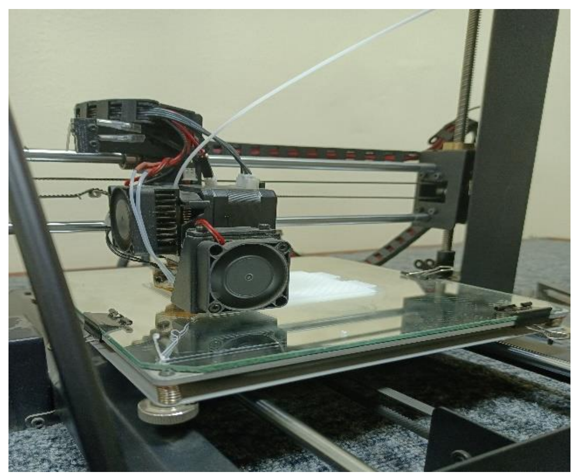


Figure 2.6 turning radius measuring mechanism and cross section of it.

This mechanism is made for measuring the turning radius during vehicle is moving on a constant speed test and it is mounted on the vehicle top.
This mechanism consists of a spur gear with gear ratio (5), The gear is attached to a potentiometer of 10 turns.
There is a pulley integrated to the pinion and it has a wire rolled around it. The beginning of the wire is connected a fixed point (Center of turning), as the vehicle moves away from the center the wire is pulled away causing rotation of the pulley then it causes the pinion to rotate that in turn rotates the gear, then the potentiometer rotates.
The potentiometer has a voltage range from (0-5) volts, as it rotates the voltage changes in between the previous range. According to the output value we can measure the turning radius.

Figure 2.7 ten turns potentiometer

Calculation of the roller disc radius:
From vehicle dynamic tests we get:
D = 5 m
For 10 turns potentiometer
$D_{\circ}$ = D/10 =0.5 m
Using spur gear with gear ratio =5
$D_{\circ}$ =0.5/5=0.1 m=10 cm
Manufacturing of the mechanism:
This mechanism is manufactured by 3D PRINTER.



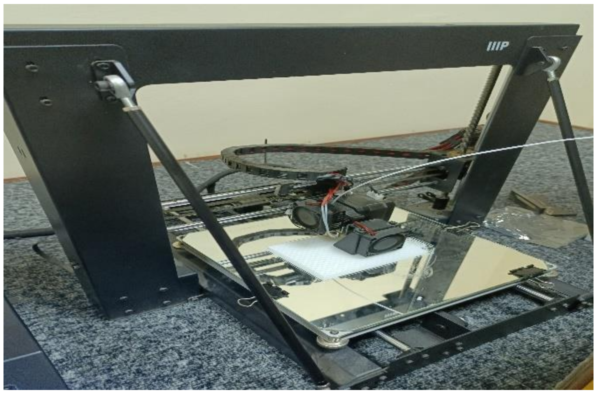


Figure 2.8 3D Printing.

Test running out:
All of the previous sensors is attached to the tested vehicle as shown in the following figure.

Figure 2.9 the tested vehicle.

All sensors signals are received by the CompactRio and is monitored on a computer.

Figure 2.10 received data.

IV-RESULTS AND DESCISION

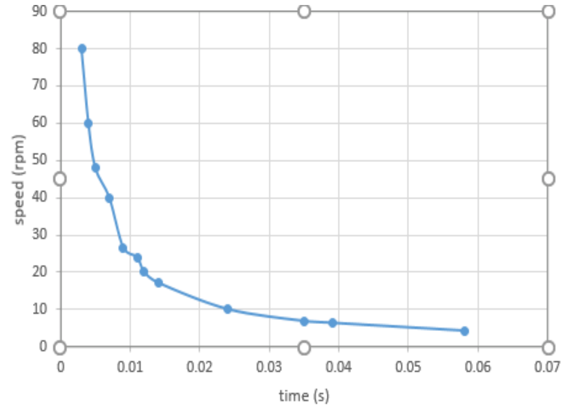


Figure 2.11 speed / time chart.

Actual velocity	=50 km/hr.
Vehicle velocity	=45 km/hr.
Slip ratio	=5%.
Elapsed time	=38 sec.
deceleration	=5.8 m/s^2
Turning radius	=5 m.

Figure 2.12 test results.

V-ACKNOLEDGEMENT

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VI-CONCULSION

This mechanism provides the ability to determine the motion parameters synchronized during accelerating, braking, ride forces and turning radius, which enables us to detect vehicle performance and stability, which helps us to improve vehicle dynamics measurements, which has a great role in improvement of vehicle industries.

VI-REFERENCES

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[2] Meywerk, Martin (2015). Vehicle Dynamics (1st. ed.). West Sussex: John Wiley & Sons. ISBN 978-1-118-97135-2. Lecture Notes to the MOOC Vehicle Dynamics of iversity.