Implementation of Data Acquisition System (DAQ) in an All Terrain Vehicle (ATV)

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Abstract - *A Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer. The following texts shows the information of the implementation of the Data Acquisition System (DAQ) for all terrain vehicle. The components of data acquisition systems include: Sensor (to convert physical parameters to electrical signals), signal conditioning circuit (to convert sensor signals that can be converted into digital signal) , Analog-to-digital converters (to convert conditioned sensor signals to digital values). The system measures various vehicle parameters by the use of sensors plugged to a microcontroller.*

Key Words: DAQ, All Terrain Vehicle (ATV), Buggy, sensor, microcontroller

1.INTRODUCTION

An off-road vehicle is considered to be any type of vehicle which is capable of driving on and off paved or gravel surface. It is generally characterized by having large tires with deep, open treads, a flexible suspension or even a caterpillar tracks. Other vehicles which do not travel public streets or highways are generally termed off-road vehicles including forklifts, tractors, golf carts, BAJA buggy etc.

Fig. 1 : Side view of an ATV

A Data Acquisition System (DAQ) is an information system that collects, stores and distributes information. It is used in industrial and commercial electronics, and environmental and scientific equipment to capture electrical signals or environmental conditions on a computer device. The system records signals from sensors, measuring physical variables in an instant of time and then the data are stored in a memory. We can obtain the following vehicle characteristics:1) Efficiency and Performance: The development of the vehicle on the track; the speed ratio of the gearbox, the efficiency of an engine 2) Dynamic loads : The various forces acting on a buggy during dynamic condition can be measured in real time data. 3) Dynamic: chassis relative changes as the speed, tilt, longitudinal and lateral acceleration. An embedded system is a special-purpose computer system intended to execute one or a few dedicated functions, frequently with real-time computing restriction.

1.2 Data to be obtained.

In this paper we have covered following parameters which needs to be validated while designing a vehicle in order to reduce the errors and enhance the performance of a vehicle.

- RPM of primary and secondary shaft to a gearbox
- Cornering and bump forces acting on buggy in dynamic conditions.
- Time taken by a buggy to cover 150ft distance in various settings of a CVT.

2. DESIGN OF SYSTEM AND IMPLEMENTATION

The main objective of the project is to use digital system including sensors and microcontrollers for calculating and validating various design parameters of an ATV. By using different sensors various parameters are recorded and compared with the calculated ones. Following systems are designed and implemented on ATV.

2.1 Gearbox primary and secondary shaft RPM

To calculate the RPM of primary and secondary shafts of gearbox, a Hall-effect sensor with magnet (neodymium) is used. The Arduino-UNO microcontroller is used for the programming of the sensor. A magnet is placed on the output shaft from the engine. The magnet is placed accordingly so that it will be in indirect-line contact with the sensor. As the shaft rotates, the sensor will record the magnetic pulses coming from the magnet. The LCD screen displayed the number of rotations by the shaft in RPM.

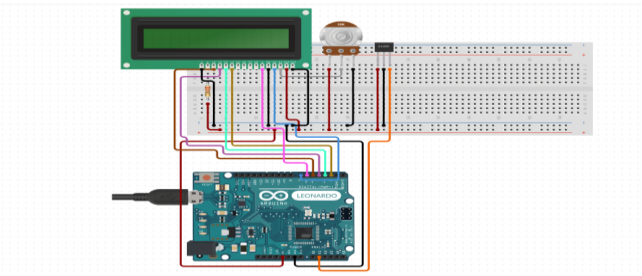

Fig. 2 : Circuit diagram for RPM measurement

2.2 Road shocks measurement

To calculate road shocks (cornering and bump force) an Accelerometer is used. Accelerometer consists of a piezoelectric crystal which works on piezoelectric effect. The road shocks will generates a proportional force on the piezoelectric crystal inside an accelerometer. This external stress on the crystal then generates a high-impedance, electrical charge proportional to the applied force and, thus, proportional to the acceleration. The Arduino-UNO microcontroller is used for the programming of the accelerometer. A transmitter and receiver module is used to transmit and receive the data when the vehicle is in running condition.

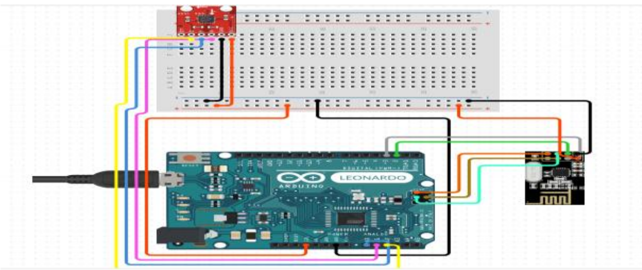

Fig. 3: Circuit diagram for road shocks measurement

2.3 Acceleration time for 150 feet distance

To calculate the time required for covering 150 feet distance, a pair of Ultrasonic sensors is used. Ultrasonic sensor sends an ultrasonic sound waves. The waves then get reflected back from the object. One sensor is placed at start point and one will be at end point. As the buggy was passed by 1st sensor, the sensor actuate and it started timer. As the buggy passed by 2nd sensor, it sent signal (via transmitter) to the receiver end to stop the timer. In this way, we have calculated the time required by buggy to cover the distance of 150 feet. A transmitter and receiver module is used to transmit the data.

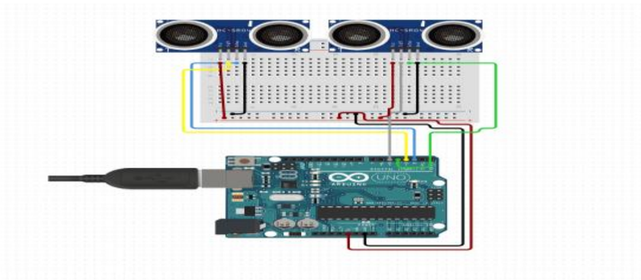

Fig. 4 : Circuit diagram for calculating time to cover 150ft distance

3. CALCULATIONS

3.1 Gearbox Input and Output RPM

To calculate the input and output RPM to a gearbox we need to calculate the gearbox reduction ratio first. In order to calculate the gearbox reduction ratio following calculations have to be carried out.

- Air resistance $(A_r) = 0.5 \times \rho \times A \times V^2 \times Cd$

  Where, ρ = density of air = 1.3 kg/cc
  A = area of firewall of roll cage = 1.059 m^2
  V = maximum speed of vehicle = 16.67 m/s
  Cd = air drag = 0.44
  $A_r = 0.5 \times 1.3 \times 1.059 \times (16.67)^2 \times 0.44$
  = 84.06 N

- Frictional force $(F_r) = \mu_r \times mg$

  Where, μ_r = coefficient of frictional resistance (for loose sand) = 0.15
  m = mass of vehicle = 200 kg
  $F_r = 0.15 \times 200 \times 9.81$
  = 294.3 N

- Gradability $(G_r) = mg \times \sin\theta$

  Where, θ = angle of grade = 34.99° for 70% of gradability
  $G_r = 200 \times 9.81 \times \sin(34.99)$
  = 1125.07 N

- Total drawbar pull (D) = $A_r + G_r$
  = 84.06 + 1125.07
  D = 1209.13 N

- Total resistance $(T_r) = A_r + G_r + F_r$
  = 84.06 + 294.3 + 1125.07

- Torque on wheel $(T_w) = T_r \times r$

  Where, r = radius of wheel = 0.283 m
  $T_w = 1503.436 \times 0.286$
  = 425.93 N-m

- Total gear ratio (CVT + Gearbox):

$$i_g = \frac{Tw}{(Te \times \eta)}$$

where, i_g = total gear ratio required

T_e = engine torque = 18.75 N-m

η = overall efficiency of transmission system = 0.9

$$i_g = \frac{425.92}{(18.75 \times 0.9)}$$

= 25.23

Now Gearbox reduction ratio is given by,

$$= \frac{\text{Total gear ratio}}{\text{CVT reduction}}$$

$$= \frac{25.23}{3.9}$$

= 6.49 ≈ 7

Therefore, required reduction ratio of Gearbox = 7

1) Engine output RPM / Input RPM to Gearbox = 4200
2) RPM on output shaft = 4200/7 = 600

3.2 Bump Forces

Considering 3G method

Vehicle mass (including driver) = 200Kg

Now, Considering 3G method,

Bump Force = Mass × Acceleration due to gravity × 3

= 200 × 9.81 × 3

= 6180.3 N

3.3 Cornering Forces

- On front wheels

$$\text{Slip Angle } (\alpha) = \frac{Wf \times V^2}{C \times g \times R}$$

Where, W_f = Weight on front wheels of vehicle = 86.25 Kg = 860.827 N

V = Max. Velocity of vehicle = 60 kmph = 16.67 m/s

g = Acceleration due to gravity = 9.81 m/s^2

R = Turning radius = 1.71m

C = Tire cornering stiffness = 79920.10112

$$\alpha = \frac{86.25 \times 16.67^2}{79920.10112 \times 9.81 \times 1.71}$$

= 0.0178 rad

= 2.03°

Cornering force on front wheels

$(F_y) = \alpha \times C$

= 0.0178 × 79920.10112

= 1437.184 N

4. TEST CAR AND IT'S SPECIFICATION

The test car used for this project is a student build ATV. It is a rear wheel drive buggy with CVT system. It is powered by Briggs And Stratton engine having 305cc and 10HP. It is a petrol engine car with the speed limitation of 60kmph.

Fig. 5 : Test car

Test car Specifications

Dry Weight	= 140 kg
Min. Weight with driver	= 200 kg
Wheelbase	= 46 inch
Wheel track	= 50 inch
Engine	= Briggs and Stratton
RPM limit	= 4200 Rpm

5. EXPERIMENTATION

The basic purpose of the project is to validate calculated data with recorded ones for the further enhancement and improvement in the performance of the vehicle. First we calculated values of above mentioned parameters using various considerations. In order to select the sensors, a detailed study of different sensors and microcontrollers is done. After detailed study of sensors, we selected different sensors to calculate different vehicle parameters.

The hall- effect sensor is used for the recording of input and output RPM to the gearbox. For this purpose, sensor is programmed accordingly. The max limit for input RPM was set as 4200 RPM whereas the max limit for output RPM was set as 600 RPM. The main consideration is to restrict the max RPM under the above mentioned limits.

The accelerometer is mounted on front left and right knuckles. For calculations of bump forces, the buggy is run on rough terrain and passed through some bumps and droops. The max recorded value for bump forces is compared with the theoretically calculated one. For calculation of cornering force, the buggy is run on rough terrain and is made to take sharp turns in order to find out the max cornering force. The max recorded value for cornering force is compared with theoretically calculated one.

A pair of ultrasonic sensor is used to record the time taken by vehicle to cover 150 feet distance. For this purpose, one ultrasonic sensor is placed at the start point and another one at the distance of 150 feet. The buggy is run several times between this sensors using different CVT tunings in order to find the best setting for getting min acceleration time.

6. RESULTS AND COMPARISON

Table -1: Comparison table

Sr. no	Parameter	Calculated Value	Recorded Value
1	Gearbox input and output RPM	Primary shaft RPM= 4200	Primary shaft RPM= 4121
		Secondary shaft RPM = 600	Secondary shaft RPM = 588
2	Bump Force	On left knuckle= 6180.3 N	On left knuckle= 5808.2 N
		On right knuckle = 6180.3 N	On right knuckle = 5800.12 N
3	Cornering force	1437.184 N	662.49 N
4	Acceleration time to cover 150 feet distance	-	5.4 sec

7. CONCLUSION

Data acquisition plays an important role in vehicle engineering design, testing and fine-tuning. There are innumerable combinations of signals, vehicle parameters, and driving characteristics that can be measured at race competitions or during practice sessions on the track. The recorded data for bump forces and cornering forces acting on knuckle is less than the theoretically calculated one which means the design for knuckle is safe. The output wheel RPM is almost same as theoretically calculated one with some minor losses. It means the calculations for RPM are upto the mark. The acceleration time for 150ft can be reduced by doing some iterations in the CVT tuning.

REFERENCES

[1] Vinoth Khanna.P,Krithika A,Revathi V – "Automobile Data Acquisition And Processing System Based on Dual CPU Architecture", International Journal of Science, Engineering and Technology Research (IJSETR), volume 2, issue 9, September-2013.

[2] Campos Vazquez, Escamilla Navaroz, Corona Ramirez - "Data Acquisition System on an off road vehicle by a programmable logic device", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), volume13, issue 6, Nov.-Dec.-2016.

[3] Luciano Boquete, Jose Manuel Rodrigez,Rafael Baria, Joaquain Quantos,Sergio Ortega,Juan Manuel Miguel – "Data Acquisition , Analysis and Transmission platform for a Pay-As-You Drive System" www.mdpi.com/journal/sensors, issue 10, June-2010

[4] Vivek Kumar Pandey, Sparsh Kumar, Vimal Kumar, Pankaj Goel- "A Review Paper on I2C Communication Protocol", International Journal of Advance Research, Ideas and Innovations in Technology (IJARIIT) , volume 4, issue 2.

[5] Guido Lopez, Anthony Seaber – "The theory and practice of race vehicle data acquisition and analysis motorsport engineering", American Society for Engineering Education (2009).

[6] Akshay G Bharadwaj, Suraj M, Lihith E, Karthik S – "Design, Analysis, Simulation and Validation of Suspension System for an Electric All-Terrain Vehicle (ATV)", International Journal of Innovative Research in Science, Engineering and Technology(IJIRET), volume 5, issue 12, December-2016

[7] A. Muni Sankar, T. Devaraju, M. Vijaya Kumar, P. Sudharshan, - "Design of High Accurate Data Acquisition System For Real Time Monitoring of Power Grid", International Journal of Scientific and Research Publications, volume 7, issue 7, July-2017