Performance Optimization of Continuous Variable Transmission (CVT) using Data Acquisition System (DAQ)

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Abstract— The Gear Ratio of CVT is Depends on change of the radius of the sheaves. It is necessary to acquire the data of the changing gear ratio with respect to changing RPM of the engine. For this purpose development of a Data Acquisition System Using Arduino ICE. This made us easier to understand the response of the CVT to Change the component which are described later. The method described on this paper can be used to optimize performance of any vehicle working with a CVT.

Keywords: DAQ, CVT, RPM, Shift Rate, Tunable Component, Roller Weights, Cams, Torsional Spring, Stiffness Springs

I. INTRODUCTION

Continuous Variable Transmission (CVT) is used in many vehicles as part of automatic transmission. This deals with methodology on how to tune the CVT as per the required Performance.

A. Terminology

1) CVT: CVT is an automatic transmission that can change seamlessly through an infinite number of effective gear ratios.
2) DAQ: Data Acquisition System
3) INT: Interrupt
4) ISR: Interrupt Service Routine
5) I/O:Input, Output
6) Photoelectric sensor
7) Tuning: Customization of CVT components for vehicle's performance.
8) Tunable Components: CVT Components which are customizable.
9) Cam: Cam is a tunable component of driven pulley (Secondery clutch).
10) Upshift: Forward shift in gear ratio of CVT, going from higher to lower gear ratio.
11) Back shift: Back shift in gear ratio of CVT, going from lower to higher gear ratio.
12) Flyweight: Tunable components in driver pulley (primary clutch) of CVT which will be working on centrifugal force.
13) Engagement Rpm: Engine rpm at which the driving pulley gets engaged with the belt.
14) Shift Rpm: Engine rpm at which the gear ratio of CVT starts shifting from a constant value. Engagement rpm is less then shift rpm.

B. Introduction and Tuning Options of CVT

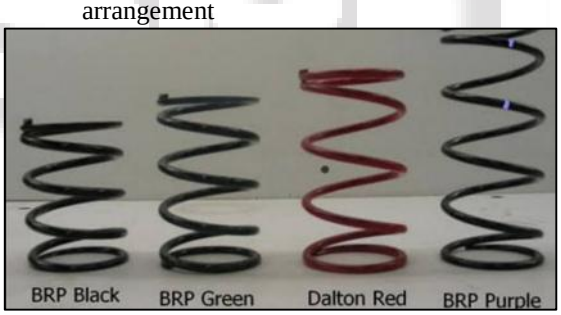
DAQ (Data Acquisition System) is collecting instantaneous responses of any CVT (Continuously Variable Transmission) driver pulley as corresponding movements of driven pulley. Static and dynamic engagement RPM, instantaneous gear ratio and the shift rate along with dynamic upshifts and the backshifts, these all parameters are dependent on the tunable components of any CVT. These components are roller weights and the stiffness springs in driver pulley(primary clutch) & the Cam and the torsion spring in the driven pulley(secondary clutch).

The DAQ is used to measure the rpm of the driven and driving pulley of the CVT. The data is used to find the gear ratio which is used for CVT tuning. The rpm of the pulleys is measured with the help of a photoelectric sensor which is one kind of IR sensor.

The CVT comes with varieties of tunable components like the roller weights of different weights, and the stiffness springs of different stiffness in drive pulley & the Cam of different angle and the torsion spring of different stiffness in the driven pulley. Which will be shown below.

Driver pulley internal arrangement

degree Cam



stiffness springs in driver pulley

Roller weights with arms.

Torsional spring

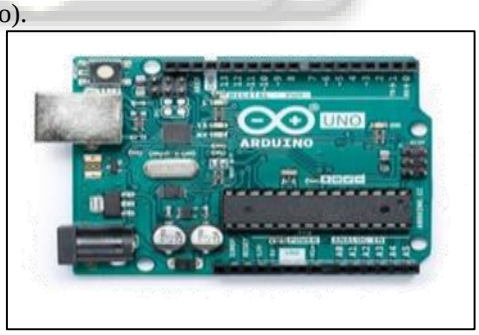
1) Arduino Uno microcontroller:

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB port. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.

II. EXPERIMENTAL PROCEDURES

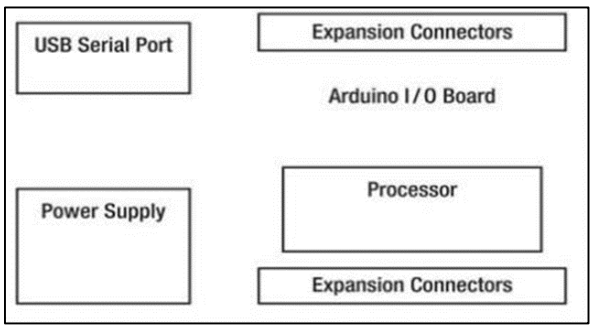
A. Procedure:

- One tape is on primary and secondary centrifugal clutch for IR sensor detection.
- The rpm of the pulleys is measured with the help of a photoelectric sensor(IR sensor).
- These sensors are mount in close parallel to the pulleys so that the sensors are capable of producing output readings.
- The Arduino Uno module was mounted in the cockpit section and data was recorded in the module.
- The output produced by the sensor is read as digital input for Arduino which consider as an external interrupt in programming.
- This input is feed into external interrupt pins of the Arduino. The inputs are triggered in programme so multiple input pulses(produced by sensor) do not take place in the same revolution.
- The time between the two rising edges is stored. The Gear ratio is defined as the ratio of rpm of driving pulley by the rpm of driven pulley(driver rpm/driven rpm =gear ratio).



- The data were recorded for Vehicle with increasing engine rpm.

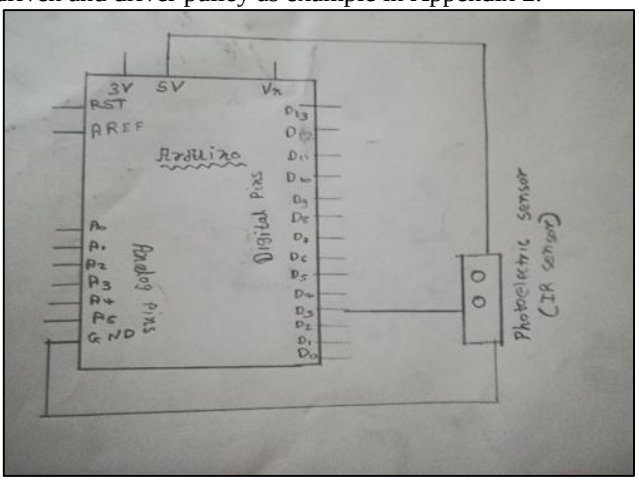
Arduino Uno microcontroller



Block Diagram of Arduino Uno

1) Observations:

The first set of data was recorded with primary stock set of the CVT. As an example of data is provided in Appendix 1. The second test was done by changing the configuration of driven and driver pulley as example in Appendix 2.



Circuit diagram

2) Conclusion

We have to tune the CVT with required parameters by tuning to get best results. The methodology will be used to get other performance parameters with other set of CVT. And program for this circuit is in Appendix 3.

1) Appendix 1

RPM of driver pulley	RPM of driven pulley	Gear Ratio of CVT
1776.756	510.393	3.48
2025.78	754.78	2.67
2408.67	1215.67	1.99
2804.7	2373.7	1.1
2871.8	3355.7	0.85

As example

2) Appendix 2

RPM of driver pulley	RPM of driven pulley	Gear Ratio of CVT
1636.87	392.67	3.24
2121.6	1059. 0	2.1
2179.4	1330.7	1.67
2871.4	3355.67	0.85
3046.35	4288.4	0.71

As example

3) Appendix 3

```
//EE_wave
//RPM_meter
float value=0;
float rev=0;
int rpm;
int oldtime=0;
int time;
void isr()                    //interrupt service routine, only in pin
number 2 or pin number 3
{
rev++;
}
void setup()
{
attachInterrupt(3,isr,RISING);  //attaching the interrupt
```



```
}
void loop()
{
delay(1000);
detachInterrupt(0);
time=millis()-oldtime;        //finding total time for one rev
rpm=(rev/time)*60000;         //calculating the rpm
oldtime=millis();
rev=0;
Serial.print("  RPM TESTER  ");    //printing on arduino
Serial.print(     rpm);
Serial.print(" RPM");
attachInterrupt(0,isr,RISING);
}
```

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