Development of Automatic Manual Transmission for Two Wheelers with Specific Reference to Motor Cycle

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Abstract - *In this technological world, there is always a demand for new inventions in any field. In the automotive industry, there is more scope for new technologies and more convenience for the passengers. The market already has a fully automatic transmission system. However, it ineffectively performs since the torque converter used to engage or disengage the gears automatically may lose power, reducing acceleration and fuel economy, making the system less reliable and requiring high initial and ongoing maintenance costs. In Automatic Manual Transmission vehicle, gears are changed automatically by a gear changing unit concerning the speed of the vehicle and engine rpm. Furthermore, the system gives the versatility of a bike and the comfort of a scooter with continuous variable transmission (CVT). This system contains sensors, transducers, and an Arduino to control the system through an Electronic Control Unit, which helps to makes the ride smooth and convenient to drive.*

Key Words: **Electronic Control Unit, Automatic Transmission, Arduino, Centrifugal Clutch**

1. INTRODUCTION

This work is based on the design and manufacture of an Automatic Gear Shifting (AGS) system for a two-wheeler and has been developed using an automatic clutch (centrifugal clutch). It minimizes the disadvantages of a manually operated transmission system. The gears are going to shifted automatically based on the speed of the vehicle and engine rpm. To accomplish this, instructions are sent from the Electronic Control Unit (ECU), which is a microcontroller with a pre-programmed. The microcontroller sends a signal to the stepper motor, which activates the specific gear based on the vehicle's speed. Even though in scooters, mopeds also have a variable transmission system. CVT's do not have the concept of meshing gears. The fuel economy is comparatively low when compared to the gear featured vehicle. The AMT system is not yet present in any motorcycle. This system provides gear shifting with an increase or decrease in speed of the vehicle.

1.1 AMT Emergence

The automatic manual transmission is a type of motor vehicle transmission that can automatically change gear ratios as the vehicle moves, freeing the driver from having to shift gears manually and allowing for more efficient driving.

Magneti Marelli, Italy, introduced AMT to India. It was first used by a Tata vehicle (Zest), and then by Maruti in the Celerio. The AMT system in the vehicles mentioned above is electro-hydraulic. This type of actuator is powered by hydraulics. The input to the ECU is provided by the vehicle speed sensor, engine speed sensor, and throttle position sensor and the gears are actuated by a stepwise rotating servo and stepper motor.

1.2 General Construction of AMT

A conventional transmission system serves as the foundation of an AMT. It is made up of several sensors, including an engine speed sensor and a vehicle speed sensor. The vehicle speed sensor measures the speed of the vehicle and sends a signal to the microcontroller unit. The microcontroller unit is the motherboard of an automated manual transmission, and it controls the stepwise rotating motor by providing pulse width. When the driver demands it, the motor's stepwise rotation shifts the vehicle's gears.

We used an embedded system instead of a hydraulic system to develop this AMT system for the BAJAJ KAWASAKI motorcycle. This system is implemented in this motorcycle through the use of a centrifugal clutch, a vehicle speed sensor, an engine speed sensor, an Arduino board, and a Johnson dc motor. We also used the LCD to check the engine's rpm, which allows us to determine which gear is being changed.

2. DEVELOPMENT OF AMT

2.1 Selection of Motor Vehicle

Continuous variable transmission (CVT) is commonly used in mopeds. Although they are simple to operate, the maintenance costs and mileage of such mopeds are not particularly user-friendly. In attempt to make AMT possible, we used BAJAJ Kawasaki bike. In which modifications are possible as per work requirement.

2.2 Gear Box

The Bajaj Kawasaki 125's gearbox is a sliding mesh gearbox with four speed gears. We made some

modifications to this vehicle's gearbox in order to develop the AMT system.
We remove the gear box's gear shifter pedal. The gears are automatically shifted by mounting the stepwise rotating Johnson DC motor on the gearbox's drum shifter. The motor is mounted on this drum shifter by mounting a shaft on the drum shifter.

Fig-1 Gearbox of BAJAJ Kawasaki

When the vehicle moves, the sensors send information to the Arduino board, which sends a signal to the motor in the form of angular movement of the motor, causing the gears to shift.

Table -1 Gear position and Ratio

Sr.No	Gear Position	Gear Ratio
1	I.	3
2	II.	1.70
3	III.	1.23
4	IV.	0.91

2.3 Development of Centrifugal Clutch

A centrifugal clutch is a clutch that connects two concentric shafts using centrifugal force, with the driving shaft nestled inside the driven shaft. At higher speeds, it engages more. The clutch's input is linked to the engine crankshaft, while the output can drive a shaft, chain, or belt.
As the engine rpm rises, the clutch's weighted arms swing outward, forcing the clutch to engage. The most common types have friction pads or shoes that are radially mounted and engage the inside of the housing rim. There are a variety of extension springs on the center shaft that connect to a clutch shoe. When the central shaft rotates quickly enough, the springs extend, causing the clutch shoes to engage the friction face.

Fig-2 Modified centrifugal clutch

The weighted arms press these discs together, causing the clutch to engage. When the engine reaches a certain speed, the clutch engages, acting in a manner similar to a continuously variable transmission. As the load increases, the speed decreases, causing the clutch to disengage, allowing the speed to rise again, and then reengaging the clutch.

2.4 Design and fabrication of centrifugal clutch

A clutch is a machine component that connects the driving shaft to the driven shaft, allowing the driving shaft to start and stop without stopping the driving shaft. The riveting process is used in this system to mount centrifugal weight on the gear. Because the crankshaft piston is engaged with the clutch gear, engine power is transmitted to the clutch gear via the crankshaft pinion. Due to the centrifugal force acting on it, the centrifugal weight is free and the power of the engine is able to transfer to the gear box. The magnitude of centrifugal force was determined by the rotational speed of the shoes. When the centrifugal force is greater than the spring force, the shoes remain in the same position as when the driving shaft is stationary. Following are the specifications of the centrifugal clutch:

1 The clutch should be able to dissipate the 8000 watts in order to keep the operating temperature within reasonable range.
2. The internal gear box should be adjusted to a range of 0.000 to 0.035 inches.
3. The clutch can withstand speeds of up to 14000rpm.
4. The non-replaceable components will be designed to last indefinitely.

2.5 Arduino Board

The ATmega 328P-based Arduino UNO is a microcontroller board. It has 14 digital input/output pins (six of which can be used as PWM outputs), six analogue inputs, two 16 MHz quartz crystals, a power jack, an ICSP header, and a reset button.

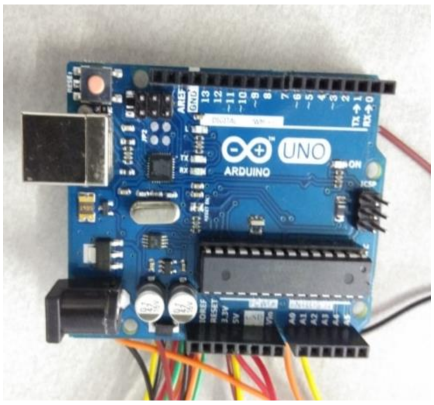

Fig-3 Arduino board

The Arduino Uno board can be powered via USB or an external power supply, and the power source is automatically selected. Moreover, external power can be supplied by an AC to DC adapter or a battery. Connect the adapter by inserting a 2.1 mm center-positive plug into the board power jack. Leads from a battery can be inserted into the power connectors' GND and Vin pin headers.
The board can be powered by an external power supply ranging from 6 to 20 volts. However, if less than 7v is supplied, the 5v pin may supply less than 5v, causing the board to become unstable. If you use more than 12V, the voltage regulator may overheat and damage the board. The recommended voltage range is 7 to 12V.
The power pins are as follows:
-Vin – the input voltage to the Arduino board when it is powered by an external source (as oppose to 5v from the USB connection or other regulated power source.) You can supply voltage through these pins, or if you're supplying voltage via the power jack, you can access it through these pins.
-5v- This pin outputs a regulated 5v from the board's regulator. The board can be powered by a DC power jack (7 to 12 volts), the USB connector (5 volts), or the Vin pin on the board (7 to 12v). The regulator is by-passed when voltage is supplying via the 5v to 3.3v pins.
The onboard regulator generates a -3V3-A.3.3 Volt supply. The maximum current draw is 15 milliamperes (mA).
-GND- pins are ground pins.
-IOREF- The voltage reference with which the microcontroller operates is provided by this pin on the Arduino board. A properly configured shield can read the IOREF pin voltage and select the appropriate power source, or it can enable voltage translators on the output to work with 5v or 3.3v.
Specifications of Arduino board:
Microcontroller-ATmega328;
Operating voltage-5V;
Input voltage(recommended)-7 to 12V;
Input voltage (limits)-6-20V
Digital I/O Pins -14(of which 6 provides PWM output)
Analog input pins-6;
DC per I/O pin-40mA
DC for 3.3V pin-50Ma
Flash memory-32kb(ATmega328) of which 0.5kb used by boot loader
SRAM- 2kb(ATmega328);
EEPROM-1kb(ATmega328);
Clock speed- 16 MHz.

2.6 Arduino Programming

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(4,5,6,7,8,9);
int x=0;
int y=0;
int z=0;
int a=0;
int c1=0;
int c2=0;
int rly=11;
int m1=A0;
int m11=A1;
int g1=0;
int g2=0;
int g3=0;
int g4=0;
void setup()
{
Serial.begin(9600);//
attachInterrupt(0, abc, RISING);
attachInterrupt(1, abc1, RISING);
pinMode(m1,OUTPUT);
pinMode(m11,OUTPUT);
pinMode(rly,OUTPUT);
lcd.begin(16, 2);
lcd.print("Welcome");
delay(2000);
lcd.clear();
}
void loop()
{
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Measuring..");
//delay(100);
x=(millis()/1000);
z=x;
c1=0;
c2=0;
y=x-z;
while(y<=3) {
x=(millis()/1000);
y=x-z; }
c1=c1*20;
c2=c2*20;
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("s1:");
```

```
lcd.setCursor(3, 0);
lcd.print(c1);
lcd.print("   ");
lcd.setCursor(0, 1);
lcd.print("s2:");
lcd.setCursor(3, 1);
lcd.print(c2);
lcd.print("   ");
delay(100);
if(c2>=1500 && g1==0)
{
g1=1;
digitalWrite(rly,HIGH);
delay(500);
digitalWrite(m1,HIGH);
digitalWrite(m11,LOW);
delay(1780);
digitalWrite(m1,HIGH);
digitalWrite(m11,HIGH);
delay(500);
digitalWrite(rly,LOW);
delay(500);
}
if(c2>=4300 && c1 >= 15 && g1==1 && g2==0)
{ g2=1;
digitalWrite(rly,HIGH);
delay(500);
digitalWrite(m1,HIGH);
digitalWrite(m11,LOW);
delay(1780);
digitalWrite(m1,HIGH);
digitalWrite(m11,HIGH);
delay(500);
digitalWrite(rly,LOW);
delay(500);}
if(c2>=5500 && c1 >= 30 && g1==1 && g2==1 && g3==0)
{
g3=1;
digitalWrite(rly,HIGH);
delay(500);
digitalWrite(m1,HIGH);
digitalWrite(m11,LOW);
delay(1780);
digitalWrite(m1,HIGH);
digitalWrite(m11,HIGH);
delay(500);
digitalWrite(rly,LOW);
delay(500);

}

if(c2>=6500 && c1 >= 50 && g1==1 && g2==1 && g3==1
&& g4==0)
{ g4=1;
digitalWrite(rly,HIGH);
delay(500);
digitalWrite(m1,HIGH);
digitalWrite(m11,LOW);
delay(1780);
digitalWrite(m1,HIGH);
digitalWrite(m11,HIGH);
delay(500);
digitalWrite(rly,LOW);
delay(500);
g3=0; }

if((c2>=5500 && c1 >= 30 && g1==1 && g2==1 && g3==0
&& g4==1))

{ g3=1;
digitalWrite(rly,HIGH);
delay(500);
digitalWrite(m1,LOW);
digitalWrite(m11,HIGH);
delay(1780);
digitalWrite(m1,HIGH);
digitalWrite(m11,HIGH);
delay(500);
digitalWrite(rly,LOW);
delay(500);
g2=0;

}

if(c2>=4300 && c1 >= 15 && g1==1 && g2==0 && g3==1
&& g4==1)
{

g2=1;
digitalWrite(rly,HIGH);
delay(500);
digitalWrite(m1,LOW);
digitalWrite(m11,HIGH);
delay(1780);
digitalWrite(m1,HIGH);
digitalWrite(m11,HIGH);
delay(500);
digitalWrite(rly,LOW);
delay(500);
g1=0;
}

if(c2>=1500 && g1==0 && g2==1 && g3==1 && g4==1)
{

g1=1;
digitalWrite(rly,HIGH);
delay(500);
digitalWrite(m1,LOW);
digitalWrite(m11,HIGH);
delay(1780);
digitalWrite(m1,HIGH);
digitalWrite(m11,HIGH);
delay(500);
```

```
digitalWrite(rly,LOW);
delay(500);

}

delay(200);

}

void abc()
{
if(y<=3)
{
c1++;
}
void abc1()
{
if(y<=3)
{
c2++;
}
```

2.7 Sensors

1.Engine Speed Sensor: The engine speed is an essential device because it provides an accurate value for engine speed. It is used to determine the engine's revolution per minute and exact crankshaft position. It is necessary to calculate the speed of the engine for the accuracy of the gear shifting mechanism.
To accomplish this, we connect a wire to the Arduino board from the pickup coil, which provides 2v pulses to the Arduino board to determine engine rpm. The pulses provided by the pickup coil is used to shift the gears.

2. Vehicle speed Sensor: An infrared sensor is an electronic device that emits light to detect certain aspects of its surroundings. An IR sensor can count the number of objects as well as to detect motion.

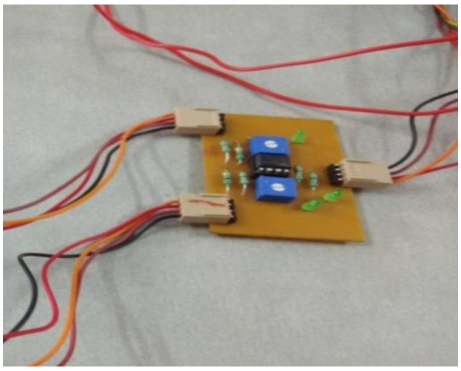

Fig 4- IR vehicle speed sensor

A vehicle speed sensor generates a magnetic pulse in the form of a wave which is directly proportional to the vehicle's speed. This information is utilized in the transmission unit to determine gear changes. We used an infrared vehicle speed sensor to shift gears automatically. Furthermore, this sensor is made up of a small LED. This LED is mounted on the wheel and can detect the vehicle's current speed.

2.8 Transmitter and Receiver

IR Transmitter: A light-emitting diode (LED) that emits infrared radiation is known as an infrared transmitter. An IR LED looks like a regular LED, the radiation it emits is invisible to the naked eye. Infrared transmitters are classified according to their wavelengths, output power, and response time.

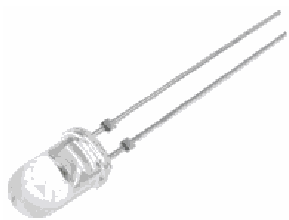

Fig.4 IR transmitter

IR Receiver: Infrared receivers are also called infrared sensors. They detect the radiation from an IR transmitter. The IR receiver is in the form of photodiodes and phototransistors. Infrared photodiodes are different from normal photodiodes as they detect infrared radiation.

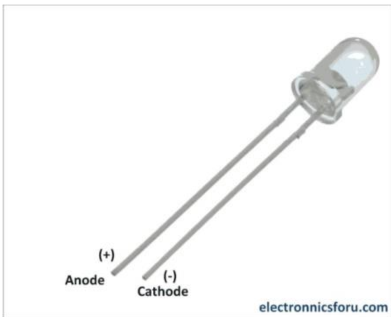

Fig-5 IR receiver

Working principle of IR sensor:

An IR sensor is made up of an IR LED and an IR photodiode, which work together to form a photo-coupler or optocoupler. When the IR transmitter emits radiation and it reaches the object, some of it is reflected back to the receiver. The sensor's output is defined based on the intensity of the IR receiver's reception. The distance between the IR LED and the IR receiver is crucial. Direct Incidence occurs when an IR LED is held directly in front of the IR receiver.

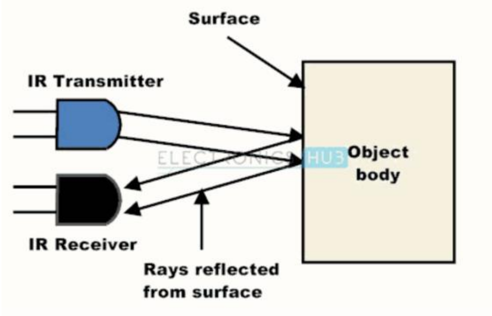

Fig-6 Working principle of IR Sensor

Almost all of the IR LED's radiation will land on the IR receiver in this situation. As a result, the infrared transmitter and receiver communicate via line of sight. When an item falls inside this line, it either obstructs the radiation from reaching the receiver by reflecting it or observing it.

2.9 DC Motor

In most automotive applications, the Johnson Electric DC motor series is the industry standard for motion actuation. This motor series serves as a foundation for bespoke engineering to fulfil a vehicle's specific needs. The reliability and overall performance of the Johnson motor brand provides a technical benchmark of excellence.

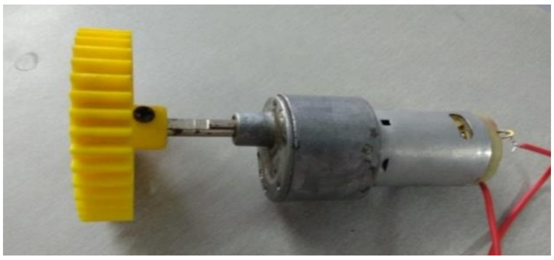

Fig-7 DC Motor

Electromagnetism is used to power electric motors. Other types of motors, however, rely on electrostatic forces or the piezoelectric effect. Motion is created by an electromagnet or armature interacting with a fixed field magnet in the case of a PMDC motor (housing assembly). Through the carbon brushes or brush leaves, electrical current travels through the motor terminals in the endcap assembly, which come into contact with the commutator in the armature assembly. The coil is powered by an electric current, which creates a magnetic field that causes the armature to rotate as it interacts with the magnet contained in the housing assembly.
Following are specifications of DC motor:

-12v DC geared motor- 10 rpm
-Product name: SI-MOT-JGDC-12V (10.0)
-Rotations per minute: 10 rpm with gearbox
-Price: 800RS.
-18000RPM based motor
-Shaft: 6mm
-Gear diameter: 37mm
-Motor diameter: 28.5 mm
-Length: 63mm without shaft
-Shaft length: 15mm
-Weight: 300grams
-No-load current: 800mili ampere (maximum)
-Load current: up to 9.5 amperes (maximum).

3. ASSEMBLY AND TESTING OF AMT

3.1 Assembly of AMT

This vehicle's AMT system consists of a DC motor, an Arduino board, an IR vehicle speed sensor, an engine speed sensor, and a centrifugal clutch. The vehicle speed sensor is mounted on the vehicle's rear wheel to detect the vehicle's running speed. Within 3 seconds, the sensor's LED detects the vehicle's current speed. The engine speed sensor is used to detect the engine's rpm and send it to the Arduino board. This signal is obtained from the pickup coil. To provide input to the Arduino board, one end of the wire is connected to the pickup coil and the other end is connected to the Arduino board

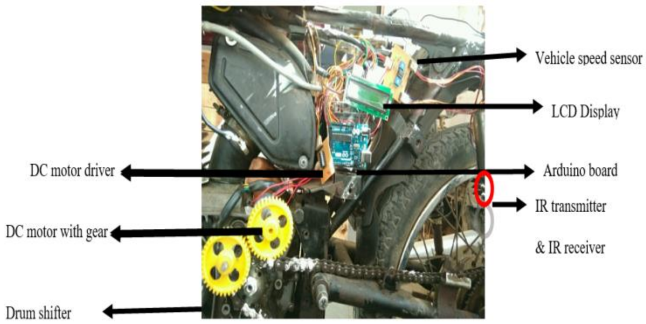

Fig-8 Assembly of AMT System in Two-Wheeler

This pickup coil typically emits 2V pulses. A microcontroller unit, such as an Arduino board, is at the heart of this AMT system. As an input signal, this Arduino board receives the signal from the vehicle speed sensor and the pickup coil about the vehicle speed and engine speed, respectively. The Arduino then converts these signal pulses into stepwise angular movement of the DC motor, allowing for the upward and downward shifting of gears as needed.

3.2 Assembly of Centrifugal Clutch

This automatic clutch is a centrifugal clutch that has been modified from a multi-plate clutch. This change is made to allow for automatic gear engagement and disengagement. The centrifugal clutch is attached to a clutch gear that is driven by the crankshaft pinion.

Fig-9 Assembly of Centrifugal Clutch

The clutch engages when the engine reaches its maximum speed. The design makes use of the centrifugal force acting on the centrifugal weight to spin the pressure weight, which engages a hub or drum linked to the gear box's main shaft.

3.3 Assembly of LCD Display

The pulses, timing, and gear position are visualized using an LCD, as illustrated in the diagram. In our project, we used 16*2 kinds with a 14-pin LCD. The LCD shows the vehicle's gear shifts as they go up and down. The microcontroller's output sends to the relays, which regulate the shifting mechanism. The pulse, timing, gear position, and action to be performed to shift the gear are all displayed on the LCD.

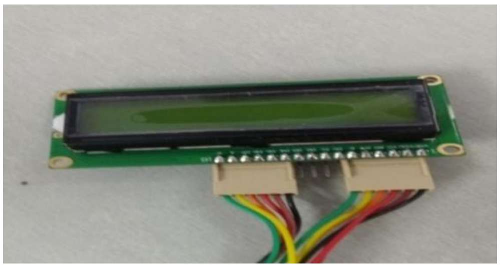

Figure 10- LCD

3.4 Testing of AMT

The testing of the AMT system of this vehicle is carried out with reference to speed range of vehicle and engine. Gear shifting is obtained with help of engine speed and vehicle speed. The first gear is shifted when the vehicle speed is 0-15 and engine speed is 1500-4300 rpm. For the second gear the condition of vehicle and engine speed is 16-30 and 1500-5500 respectively. According to the driver command the third gear is shifted when the vehicle speed is 31-50 and engine rpm is 1500-6500. For the fourth gear the vehicle speed is above 50 and engine rpm is ranging from 1500-7200 rpm. The DC motor condition for the shifting of gears are as follows:
For 1st gear-72 degree
For 2nd gear-144 degree
For 3rd gear-216 degree
For 4th gear-288 degree
According to the condition mentioned above we test the motor cycle, either gear is shifted automatically or not. For this we take the test drive of this vehicle and the testing of this motor cycle for the automatic gear shifting is successful.

4. CONCLUSION

We were able to acquire a comfortable ride setting after reaching the ideal gear shifting technology without any driver's gear shifting movement. In addition, the fuel efficiency has improved. This type of gear requires less manufacturing and maintenance than conventional two-wheeler gears. To avoid manual gear shifting, traditional technology has been improved with the use of Arduino and centrifugal clutch. As a result, it is simple to drive the bike without changing gears. Furthermore, maintaining an appropriate pulse range, as described in the programmed, and maintaining a constant vehicle speed resulted in improved fuel efficiency.

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