

# Automated Gear Transmission in Two Wheelers Using Embedded System

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**Abstract** - In worldwide the motorcycle is the only engine based vehicle which is used on large scale particularly in INDIA. Motorcycle is also varies in two large section gear transmission & CVT transmission. The recently conducted survey shows that CVT are in demand compared to the gear featured bikes. CVT's do not have the concept of meshing of gears which enhances a smooth ride, but the fuel efficiency is comparatively lesser when compared to the gear featured vehicles. Automation of gears transmission can be achieved by embedded system. Embedded system is a special purpose computer system. Embedded system is preferable because it can reduce the number of electrical components and probability of failure is minimum. Either a microprocessor or a microcontroller is used in all the embedded systems. The encoding is done by using suitable software for writing assembly level language in microcontroller which is stored in ROM of microcontroller. Embedded 'C' language is used to encode microcontroller or microprocessor.

**Key Words:** Embedded system, microcontroller, CVT (Continuous Varying Transmission), ROM, Microprocessor.

## 1. INTRODUCTION

In any other normal motorcycle the gear box is used for transmitting the torque from engine crankshaft to the rear wheel of the motorcycle. It can vary the torque according to the different driving conditions i.e. gear box increases torque at the start of the vehicle as it required for the vehicle to put in motion. After the vehicle is in motion there is no need to high torque so it will transmit optimum torque to the rear wheel for that instance of speed. Some other factors are also used while shifting the gear such as foot gear paddle used for shifting the gear and hand clutch for engaging and disengaging of flywheel. In short smooth driving of motorcycle there is need to time these two operations perfectly. And this entire cycle for gear change is can be so much tiresome for somebody particularly new driver. Therefore automated gear shifting system not only reduces accidents but also increases engine and fuel efficiency.

In our embedded system both gear paddle and clutch is actuated by using Electro-mechanically AVR based microcontroller system. Since the whole arrangement is placed outside of the system, there is no need to do modification in the engine.

This automated principle is working on acceleration of the bike. As acceleration increases RPM sensor will detect &

counts the revolutions per minute. According to the RPM counted by sensor the embedded system will decide which gear is preferred for the smooth drive of vehicle and according to the output calculated by system the gear are changed. It can also eliminates the shortcoming such as 'Knocking' and subsequently increases engine life span, Hence by Automating the gear transmission in a gear featured bike, ease in driving and also to maintain the efficiency of the bike can be achieved.

## 2. GENERAL COMPONENTS

### 2.1 Proximity Sensor

A proximity sensor is a device which detects the presence of nearby objects without any physical contact. It often emits an electromagnetic field or a beam of electromagnetic radiation (infrared), and looks for changes in the field or return signal. Different proximity sensor targets demand different sensors. In our case, an inductive proximity sensor always requires a metal target. The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.



Fig -1: Proximity Sensor



Fig -2: Fabricated Proximity Sensor on rear wheel

### 2.2 LCD Display

A liquid-crystal display (LCD) is a flat-panel display or other electronic visual display that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly. Alphanumeric displays are used in a wide range of applications, including palmtop computers, word processors, photocopiers, point of sale terminals, medical instruments, cellular phones, etc. The 16 x 2 intelligent alphanumeric dot matrix display is capable of displaying 224 different characters and symbols. Figure 3 specifies the LCD display with pin configurations. These configurations are connected to the microcontroller to display necessary parameters.

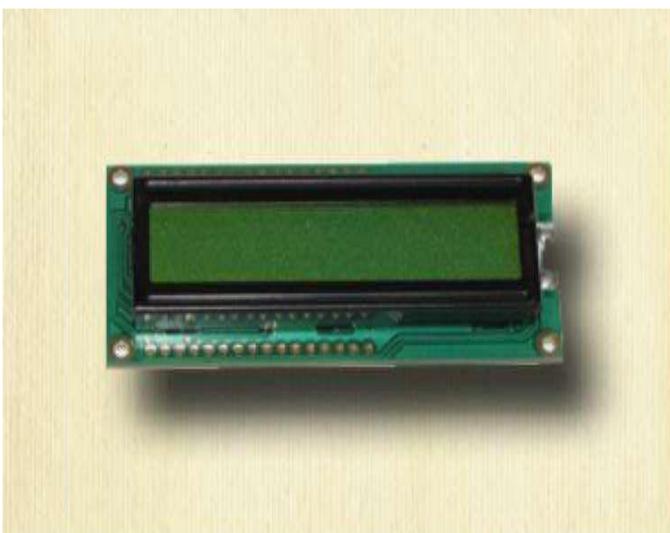


Fig -3: LCD Display

Table -1: LCD Display pins

| PIN  | SYMBOL  | FUNCTION              |
|------|---------|-----------------------|
| 1    | VSS     | GROUND                |
| 2    | VDD     | SUPPLY VOLTAGE        |
| 3    | V0      | CONTRAST SETTING      |
| 4    | RS      | REGISTER SELECT       |
| 5    | R/W     | READ/WRITE SELECT     |
| 6    | EN      | CHIP ENABLE SIGNAL    |
| 7-14 | DB0-DB7 | DATA LINES            |
| 15   | A/Vee   | GROUND FOR BACK LIGHT |
| 16   | K       | VCC FOR BACK LIGHT    |

### 2.3 Relays

Relays come in various configurations for their switch contacts, as well as different DC voltages to operate their coils. They may be as simple as an on/off switch or as complex as integrating several switches into one unit. They are classified under electromagnetic switches. Two relays of 5V and 10A are used in our gear shifting mechanism. As shown in Figure 5. The first relay is used for up shift of gear and the second relay is used for down shift of the gears. Relays are devices which allow low power circuits to switch a relatively high current and voltage ON/OFF. For a relay to operate a suitable pull-in and holding current should be passed through its coil. Generally relay coils are designed to operate from a particular voltage at 5V or 12V. The NPN transistor BC547 is used to control the relay. The transistor is driven into saturation (turned ON) when logic 1 is written on the port pin thus turning ON the relay. The relay is turned OFF by writing logic 0 on the port pin. A diode is connected across the relay coil to protect the transistor damage due to back EMF generated in the relays inductive coil when the transistor is turned OFF. The LED is used to indicate that the relay is turned ON or OFF.

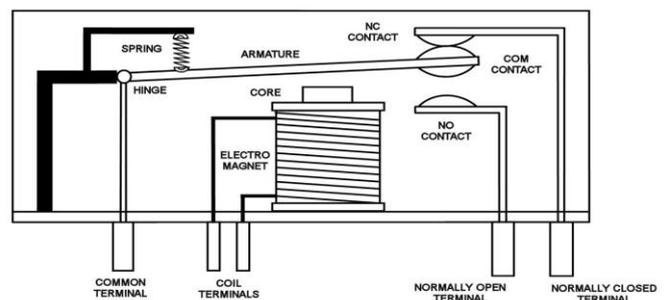


Fig -4: Relay Schematic



Fig -5: Relay circuit

## 2.4 Microcontroller

The Atmel 8-bit AVR RISC-based microcontroller combines 32 kB ISP flash memory with read-while-write capabilities, 1 kB EEPROM, 2 kB SRAM, 23 general purpose I/O lines, 32 general purpose working registers. The Atmel 8-bit AVR RISC-based microcontroller combines 32 kB ISP flash memory with read-while-write capabilities, 1kB EEPROM, 2 kB SRAM, 23 general purpose I/O lines, 32 general purpose working registers.

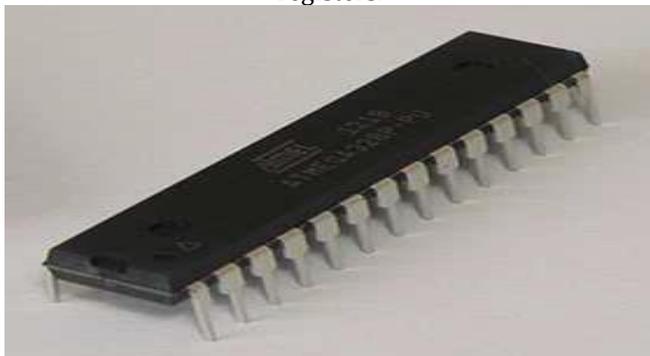


Fig -6: Atmel 8-bit AVR Microcontroller

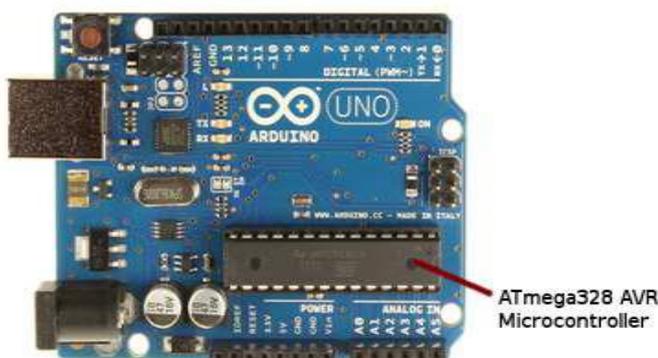


Fig -7: Microcontroller mounting on Arduino board

Three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. The device achieves throughput approaching 1 MIPS per MHz. The pulses ranges mentioned in the table 2 were obtained by trial and error method according to the city traffic conditions. The Embedded C program is burnt into the microcontroller using Proteus software.

Since the microcontroller is reprogrammable, it can be burnt until a program with necessary pulses range is implemented into it.

Table -2: Gear positioning with respect to rear wheel RPM

| PULSE RANGE | GEAR POSITION        |
|-------------|----------------------|
| 10          | 1 <sup>st</sup> gear |
| 10 to 25    | 2 <sup>nd</sup> gear |
| 25 to 35    | 3 <sup>rd</sup> gear |
| 35 & above  | 4 <sup>th</sup> gear |

## 2.5 Stepper DC Motor or Starter Motor

Specifications: Power: 12V

RPM: 500

A suitable Stepper DC motor is used to move the gear pedal. Necessary modifications are made to the gear pedal to obtain the shifting with respect to the DC motor. The DC motor is connected to 12V power supply and runs at 500rpm. The DC motor fabricated to the motor bike is shown in the Figure 8. The starter motor is attached above the bike engine. It is operated by giving the power supply from the motor bike battery.

The Stepper DC motor or a starter motor is connected to the relays. Relay 1 and 2 are actuated with respect to the program to rotate the DC motor in anticlockwise (up shift) and clockwise (down shift) motion. The gear, pitch diameter 25mm, on the DC motor is meshed with the gear pedal with timing chain. The gear pedal is fitted with spur gear of 80mm pitch diameter. When the DC motor rotates anticlockwise with 45° inclination, the pedal rotates with 25°. This inclination is sufficient is to push the pedal down to achieve the up shift during driving. Similarly, the DC motor rotates clockwise with 45° of inclination when relay is actuated. This enables the gear pedal to move in clockwise direction and the down shift is achieved.



Fig -8: Stepper DC Motor or Starter Motor

### 3. AIM, OBJECTIVES AND METHODOLOGY

The literature review clearly indicates the gap in fabrication of the automated manual gear shifting mechanism in the conventional motor bikes, in order to bridge this gap gear shifting mechanism is designed and fabricated in the following project work.

**Aim:** To design and fabricate the automated manual gear transmission in motor bikes.

**Objectives:**

1. To design the gear shifting mechanism and modify the vehicle according to the designed mechanism.
2. To program the microcontroller according to the needs of the mechanism and build the electronic circuit.
3. To calibrate the gear shifting mechanism and also to check for the improvements in the efficiency if any.

**Methodology for objective-1:**

The between the Stepper DC motor and gear pedal is designed. The Stepper DC motor is fitted about the pedal with calculated offset.

**Methodology for objective-2:**

AVR Atmel microcontroller is programmed using Arduino IDE and burnt using Proteus software. Electric circuit is built using some of the components like proximity sensor, microcontroller, LCD display unit, relays and DC Stepper motor.

**Methodology for objective-3:**

The calibration of automatic gear shifting, with is respect to rear wheel speed, in the C program by trial and error method. The efficiency of the gear vehicle in terms of mileage is tested; it has to be more than the normal CVT vehicles.

### 3.1 Literature review

The study of following research papers is done:

- I. Modeling of an embedded system of automated manual transmission.
- II. Development of an embedded system of automated manual transmission
- III. Development of a New Automatic Gear Selecting Machine for motorcycle.
- IV. Gear positioning with respect to rear wheel speed.

## 4. PROGRAMMING

### 4.1 Proteus

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.



Fig -9: Proteus software

The micro-controller simulation in Proteus works by applying either a hex file or a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables its use in a broad spectrum of project prototyping in areas such as motor control, temperature control and user interface design. It also finds use in the general hobbyist community and, since no hardware is required, is convenient to use as training or teaching tool.

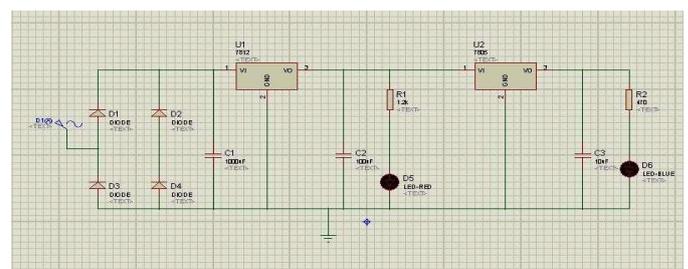


Fig -10: Power regulating circuit interface in proteus

Support is available for co-simulation of Microchip Technologies PIC10, PIC12, PIC16, PIC18, PIC24, dsPIC33 Microcontrollers. Atmel AVR (and Arduino), 8051 and ARM Cortex-M3 Microcontrollers NXP 8051, ARM7, ARM Cortex-M0 and ARM Cortex-M3 Microcontrollers. Texas Instruments MSP430, PICCOLO DSP and ARM Cortex-M3 Microcontrollers.

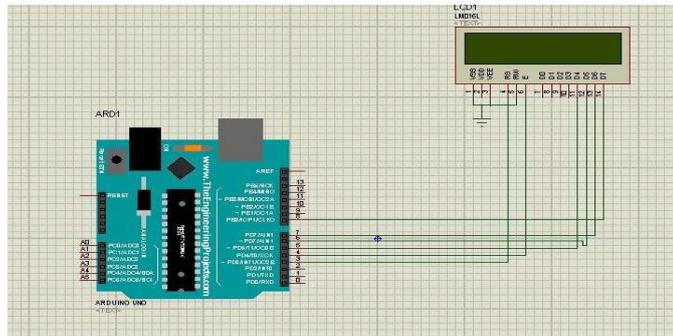


Fig -11: Arduino lcd display interface in proteus

### 4.2 Arduino IDE

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the

Physical and digital world. The project's products are distributed as open-source hardware and software.

Arduino microcontrollers are pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory. The default bootloader of the Arduino UNO

is the opti-boot bootloader. Boards are loaded with program code via a serial connection to another computer.



Fig -12: Arduino IDE

Some serial Arduino boards contain a level shifter circuit to convert between RS-232 logic levels and transistor-transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards,

substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to-serial adapter board or cable, Bluetooth or other methods. When used with traditional microcontroller tools, instead of the Arduino IDE, standard AVR in-system programming (ISP) programming is used. The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits. The Diecimila, Duemilanove, and current Uno provide 14 digital I/O pins, six of which can produce pulse-width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields are also commercially available.

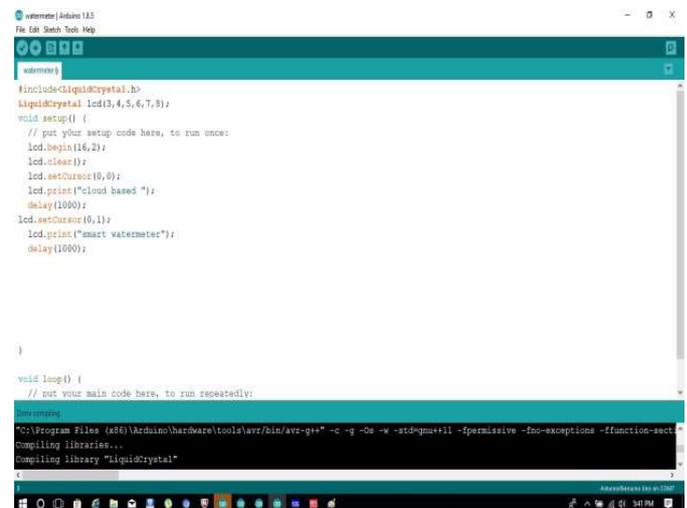


Fig -13: E.g. Arduino IDE coding

### 4.3 Program Flowchart

Program is written into the microcontroller to make the manual transmission to an intelligent transmission. The 'C' program is complicated to be understood at a single glance. So, for understanding the concept, the embedded program is represented in a basic flowchart. It includes the gear changing cycle of our project concept. This cycle is with respect to the delay time of 8 seconds. The flowchart starts when the electronic circuit is switched on by starting up the bike. The input from the sensor is represented in the flowchart. The input is in term of pulses per 8 seconds time count. The gear position is decided by the pulse range which are segregated in four different 'IF' conditions. The position of the gear is actuated when one of the conditions is satisfied.

**For example**, if the pulse range is 27 per 8 seconds then the third 'IF' condition is satisfied and the gear 3 is actuated (YES) by switching on the relay. The input is counted for every 8 seconds so the program is represented as closed loop in the flowchart. If the pulse range is not satisfied in the

'IF' condition (NO) then the range is compared with the next 'IF' condition. Expertize in new code development, University support to the needed; have been mentioned in this paper.

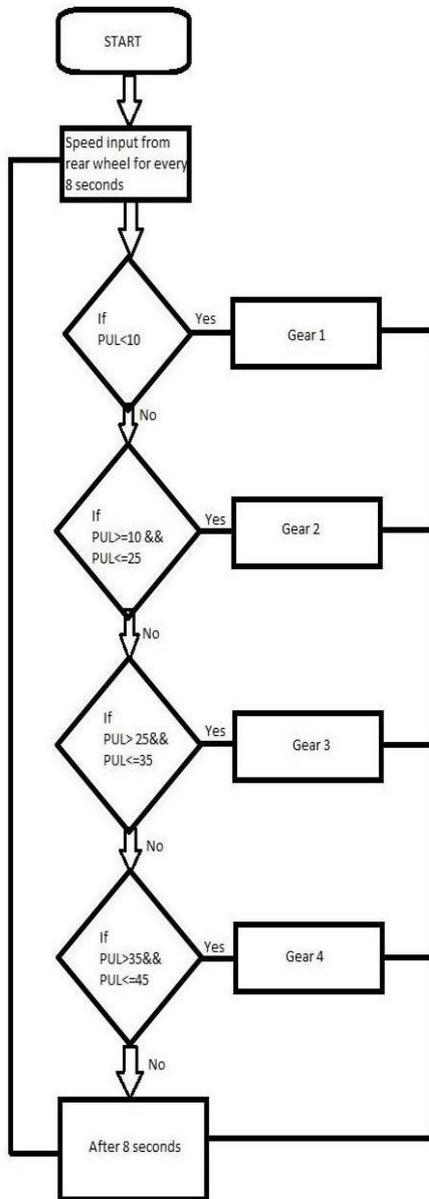


Fig -14: Flowchart of 'C' Program

## 5. MANUFACTURING AND DESIGN

### 5.1 Motor and Pedal

The Stepper motor is coupled with gear pedal by using coupler tighten by using Allen key which can use to shift the pedal either front or back by supplying power by conventional vehicle battery.



Fig -15: Motor coupled with paddle

### 5.2 Electronic circuit

Figure 16 is the electronic circuit, with all components connected as required for gearing shifting technology. The power supply for the following electronic circuits do not require any external power supply from battery. The necessary power can be drawn from the battery of the motor bike. All the components are connected using different types of wires. The electronic components are fixed within the box of the motor bike.

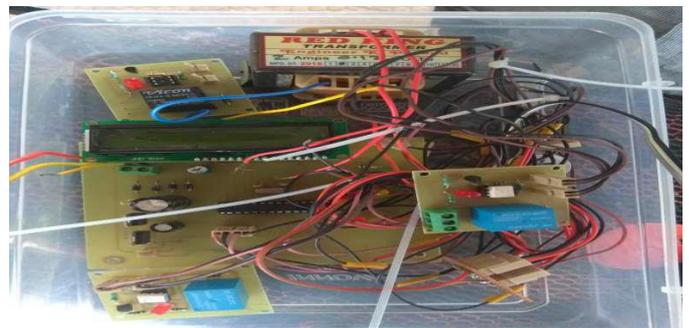


Fig -16: Complete electronic circuit attached to the bike

Table -3: Components in the circuit

| SR. NO. | PARTICULAR                         |
|---------|------------------------------------|
| 1.      | Voltage regulator 12v DC to 5v D C |
| 2.      | Liquid crystal display with board  |
| 3.      | Microcontroller ATM328             |
| 4.      | Relay for upward shifting          |
| 5.      | Relay for downward shifting        |

## 6. RESULTS AND DISCUSSIONS

### 6.1 Field Test Results

#### i) Up shifting conditions:

Table -4: Tested up shifting conditions

| FIELD TEST RESULTS |              |        |       |               |        |
|--------------------|--------------|--------|-------|---------------|--------|
| SR. NO.            | INITIAL GEAR | PULSES | SPEED | GEAR CHANGING |        |
|                    |              |        |       | FROM          | TO     |
| 1.                 | First        | 18     | 14    | First         | Second |
| 2.                 | Second       | 26     | 24    | Second        | Third  |
| 3.                 | Third        | 38     | 36    | Third         | Fourth |
| 4.                 | Fourth       | 48     | 45    | No shifting   |        |

#### ii) Down shifting conditions:

Table -5: Tested down shifting conditions

| FIELD TEST RESULTS |              |        |       |               |        |
|--------------------|--------------|--------|-------|---------------|--------|
| SR. NO.            | INITIAL GEAR | PULSES | SPEED | GEAR CHANGING |        |
|                    |              |        |       | FROM          | TO     |
| 1.                 | Fourth       | 28     | 25    | Fourth        | Third  |
| 2.                 | Third        | 14     | 12    | Third         | Second |
| 3.                 | Second       | 8      | 4     | Second        | First  |
| 4.                 | First        | 4      | 1     | No shifting   |        |

### 6.2 Experimentation

Initially the bike chosen for our experiment was driven for about 10 kmphs to check the condition of the vehicle. About 100 ml of petrol was put into the vehicle tank for checking the mileage in manual gear transmission mode. The mileage was about 5.5 kmphs. After the gear transmission was automated a few test runs were driven, the gear transmission was not effective as the speed range was not appropriate. So the speed range for the gear shift to happen was changed in the embedded C program several times by trial and error method, until the smooth gear transmission was observed. Later when the gear transmission was automated again the same test was conducted with 100 ml of petrol which was better compared to manual mode as it increased to about 5.9kmphs.

### 6.3 Review on literature survey

From the review of the journals and papers we have understood that the automatic transmission vehicles are more in demand but less fuel efficient. So, automation of manual vehicles can smoothen the driving and improve efficiency. The microcontroller is major component that need to be programmed. Linear actuators can be used to punch the pedal for shifting the gears but it consumes more power from the battery. The vehicle can be provided with two modes of driving, manual and automated mode. This technology can be implemented in auto-clutch bike as well as in clutch featured bike.

## 7. CONCLUSION AND FUTURE WORK

### 7.1 Conclusion

After achieving the desired gear shifting technology, we ever able to get a smooth ride in all city conditions. We have found that there is an improvement in the fuel efficiency. This gear shifting technology has improvised the auto-clutch featured bike into automatic transmission vehicle. The complete gear changing mechanism has been controlled by the acceleration of the bike. The vehicle can be used in manual mode by switching off the power supply to the electrical components. A switch has been provided for this optional mode.

The programmed embedded 'C' codes, in the microcontroller, were optimized and were the key source for changing gears in city limits as well as highways. Maintaining a proper pulse range, as in the program, or a constant speed of the vehicle resulted in better fuel efficiency. Fuel efficiency has been improved by 2km to 4km. After implementing this technology we have come to a conclusion that no human operation is necessary, other than accelerating, to ride the motor bike.

### 7.2 Future Work

#### 7.2.1 Implementing in all gear featured bike

The automated gear shifting mechanism can be obtained in any auto-clutch featured bike by installing the necessary electrical circuit and by fabricating. Also this mechanism can be achieved in clutch featured bikes by automating the clutch initially. The cost of installation will be comparatively high in clutch featured to wheelers. Automobile companies can manufacture bikes with this new concept on customs' demand.

## REFERENCES

[1] R. Hembree, "SEMI-AUTOMATIC ELECTRIC GEAR SHIFTING APPARATUS FOR A MOTORCYCLE". United States 15 July 1975.

[2] U. M. Friedrich Raff, "SHIFTING ARRANGEMENT FOR AN AUTOMATIC TRANSMISSION OF A MOTOR VEHICLE". United States 3 Sep 1991.

[3] David G. Funk, "PUSHBUTTON SOLENOID SHIFTER". United States of America Patent 6070485, 6 Jun 2000.

[4] P. Alexander M.E, "AUTOMATIC GEAR TRANSMISSION IN TWO WHEELERS," vol. 3, no. 2, 2012.

[5] Oliver J. Tysver, "AUTOMATIC GEAR SHIFTING MECHANISM FOR MULTISPEED MANUALLY POWERED VEHICLES". United States 28 Dec 1999.

[6] Francis G. King, "AUTOMATED MANUAL TRANSMISSION SHIFTER WITH ELECTRONIC CONTROL ACTUATORS EXTERNAL OF THE VEHICLE". United States of America Patent 4554824, 26 nov 1985.

[7] Robert E. LaWrie, "AUTOMATED MANUAL TRANSMISSION SHIFT SEQUENCE CONTROLLER". United States 1 Feb 2000.

[8 ] Pierre A. G. Lepelletier, "MULTISPEED AUTOMATIC TRANSMISSION FOR AUTOMOBILE VEHICLES". United States 21 April 1992.

[9] Luigi Glielmo, "Gearshift Control for Automated Manual Transmissions," IEEE /ASME, vol. 1,p. 11, 2006.

[10] Y.Huang, "Hybrid intelligent gearshift control of technical vehicles based on AGA-NN," International Journal of Control and Automation, vol. 6, no. 4, p. 14, 2013.

[11] C. X. Zhenyu Zhu, "EXPERIMENTAL STUDY ON INTELLIGENT GEAR SHIFTING CONTROL SYSTEM OF CONSTRUCTION VEHICLE BASED ON CHAOTIC NEURAL NETWORK". China 29 Jun 2003.

[12][https://www.researchgate.net/publication/317348920\\_AUTOMATIC\\_GEAR\\_SHIFTING\\_MECHANISM\\_IN\\_TWO\\_WHEELERS](https://www.researchgate.net/publication/317348920_AUTOMATIC_GEAR_SHIFTING_MECHANISM_IN_TWO_WHEELERS)