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Development of Low Cost Electronic Gear Shifting System with Clutch Operation for Sequential Gearbox

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ABSTRACT

This paper aims at development of low cost electronic gear shifting for 2 wheelers and student automotive designing competitions, which uses sequential gearbox for power transmission purpose. This system presents an alternative of existing electronic gear shifting mechanism which costs around ($200-$300) with the system regressing cost to**(**$35-$40**).**This electronic gear shifter system consists of two motors controlled by ATmega16 which enables gear shifting and clutch operation. One of the motor is mounted on the selector rod enabling the gear shifting whereas the other is replaced on the clutch wire assembly. These motors draw current from the battery and are actuated by an algorithm governed through different IC'S after getting a signal for changing the gears.

General Terms

This paper is about electronic automatic gear system with clutch operation for sequential gearbox and involves control system and algorithms for the same.

Keywords

Pedal shifter, sequential gear box, clutch, Atmega, IR, L293D, Relay, Worm Gear Motor

1. INTRODUCTION

Conventionally, gear shift is done by hand/foot lever while clutch being operated hand/foot before and after the gear shift is done. A person needs to be skilful for proper coordination between clutch engagement/disengagement and throttle. Thus people choose bulky CVT (continuously variable transmission). But in cvt due to belt slippage engine power is lost thus giving lower fuel economy as compared to manual gear system. In racing environment conventional operation requires driver to take his hand off the steering wheel causing disturbance in driver's focus, less stability and fatigue. Also the time taken for shifting is more. The conventional solution for automatic gear shifting is a pedal shifter which is shifts gear using solenoid. These systems are effective but highly expensive thus limiting their use in budget constraint applications.

The proposed design solves this problem by redesigning the entire system on cost effective lines. The new system operates both clutch and gear with the press of button. A specialised system for troubleshooting is also incorporated. Thus it solves the tight budget constraints of students. Also this reduces the time for making shifts. Thus, increasing the acceleration. With minor changes system can also be installed in any day to day vehicle containing sequential gear box thus serving people with disability. It improves driver's concentration making safer driving and reduces fatigue of driver thus giving comfortable drive.

2. MAJOR COMPONENTS:

Table 1: Major Components in the system

1.	AT mega 16	Central CPU
2.	L293D IC	Motor Driving IC
3.	SPDT Relay	12 V – 10 A
4.	Motors	For Clutch and Gear Operation
5.	IR Transmitter	Controlling motor's rotational limits
6.	LM7805 IC	Provides 5 V source where ever requires
7.	LEDs	For Troubleshooting System
8.	IR Receiver	Controlling motor's rotational limits

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Fig 1: General Gear Shifting Sequence

The Motor being installed in the system is a 12 V DC worm gear motor (108 kg-cm stall torque), 60 rpm at no load. High torque 12 v DC Motors draw high current (10-12 amp) thus are directly driven by connecting to battery of the vehicle. The high current carrying wires have to small in length to minimize power losses, that's why there is a need to develop actuating mechanism so that ,controls can by mounted in steering wheel or handle. Therefore, motors are directly connected to12v battery through relay, and relay actuation is controlled by microcontroller. Henceforth the trouble of running high current carrying wires to steering system is eliminated making system safe.

While shifting gears selector rod is rotated to clockwise or anticlockwise direction for high or low shifts. Then it automatically reverts back to its central position. If the selector rod does not comes to its central position, next shift cannot be achieved. In conventional solenoid shifting mechanisms current actuates the solenoid which causes the gears to shift and in tandem to this, mechanical gear system pushes back the solenoid as a result of which the selector rod attains its neutral position.

After market research worm gear dc motor was selected as a low cost alternative to the solenoid. A small constraint with the worm gear motor is that it's shaft could only be turned by electric current, but doesn't rotate if tried by applying force manually with no current on (In worm gear system, worm can only rotate the wheel, reverse is not possible). Therefore, gear box cannot revert back to neutral position unless reverse current is applied. Motors with other reduction systems for same torque were five times more expensive .Therefore polarity has to be switched. This problem has two possible solutions:

1) Accurately Timing clockwise and anticlockwise rotation. Torque needed for shifts vary with each gear and conditions. Motor rpm also vary under load. Therefore, pre-defined set timing values of clock wise and anticlockwise rotation will make system less reliable, leading to incomplete shifts. So a feedback system was incorporated to give microcontroller signal for extreme and neutral positions, eliminating need for constant time making system dynamic to requirement. Therefore, reliability is increased.

2) Feedback System: IR photodiode is mounted on the shaft of motor and 2 IR receivers are placed at both extreme positions and one at central position. Hence system can generate a feedback signal when transmitter and receiver align. Thus, even if required torque to shift varies, still system is reliably operational.

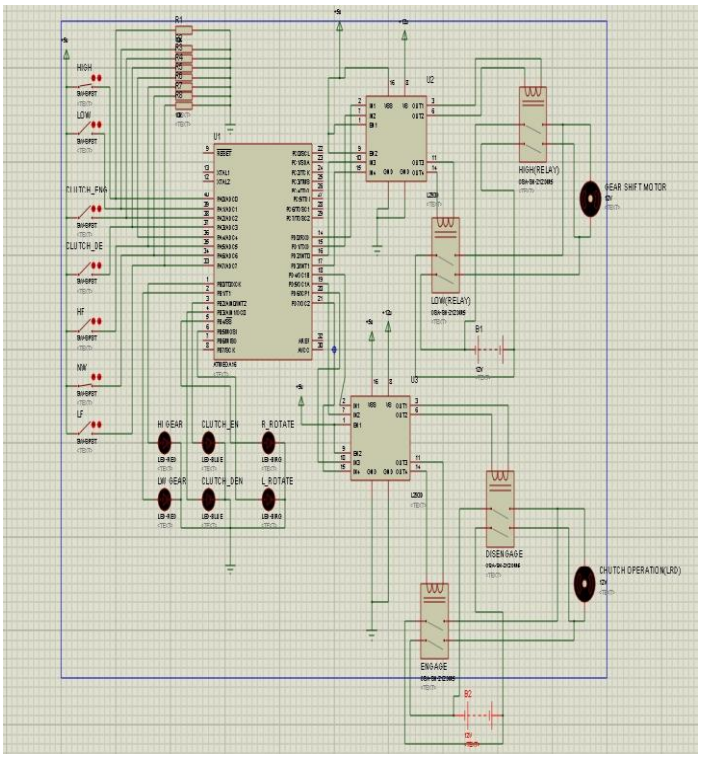

Fig 2: Main circuit governing the model

3. Process of Functioning:

1.) Power on clutch motor to start disengagement of clutch.
2.) Keep power on and wait for signal (generated by IR sensor pair in clutch motor) which tells that clutch is fully disengaged.(Figure 3)

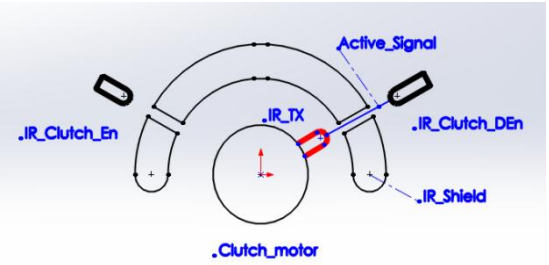

Fig 3

3.) Stop clutch motor(motor will hold this disengaged position due to worm gear reduction system as discussed above).
4.) Rotate (power on) gear shifter motor form central to higher/lower shift position.
5.) Keep it on till IR sensor (gear shifter sensor assembly) generates signal for complete rotation, i.e. motor is towards extreme higher position. When signal is received revert direction of current.(Figure 4 for high shift , figure 5 for low shift)

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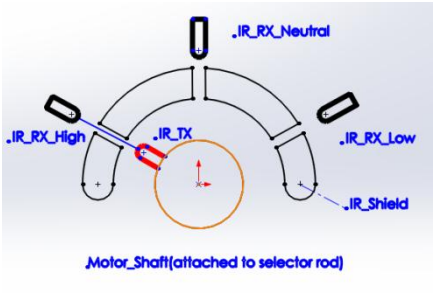

Fig 4

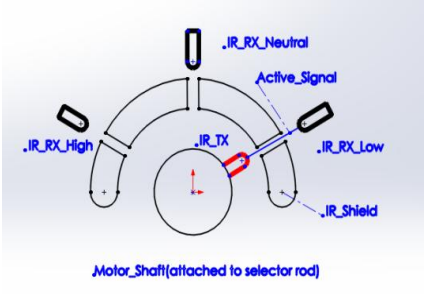

Fig 5

6.) Now wait till gear motor reaches its central position. Then halt gear motor (had the motor been rotated further from the central position then it would have reached other extreme end, therefore, shifted gear would have been drawn back).(Figure 6)

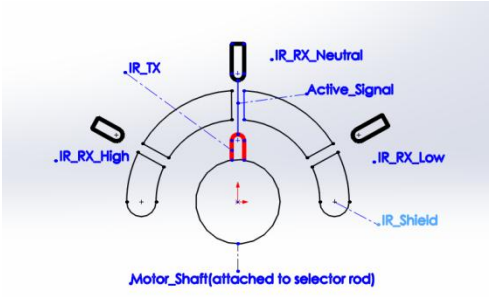

Fig 6

7.) Now, gear in engaged, reengage clutch slowly at a desired rate to avoid sudden shock by using PWM (clutch motor).

8.) Power on clutch motor towards engagement, till signal (IR) is received.(Figure 7)

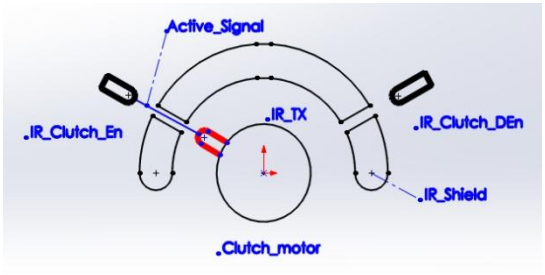

Fig 7

9.) When engagement signal is received, stop clutch motor.

10.) Gear is now completely shifted.

Since, there are multiple steps to shift gear, in case of malfunction it will be difficult to identify, the problematic step. Therefore, system is also designed for quick identification of problem. For making system cost effective LED's have been used as a replacement for LCD to display the process that is being carried.

4. LED SYSTEM:

This system uses in total 6 LEDs:

- 2 for indicating gear shift (Higher or lower)
- 2 for clutch positions (engaging and disengaging)
- 2 for gear motor rotation direction (clockwise and anticlockwise).

Glowing Led represents that the process that is being carried on. So if the gear is not shifting, looking at leds it can be easily identified where actually there is fault

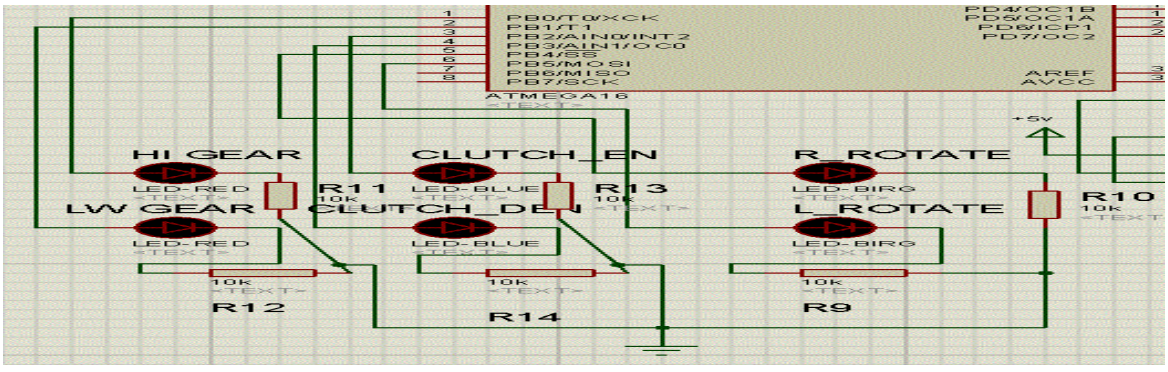

Fig 8: Troubleshooting system

5. Flowcharts and Algorithm:

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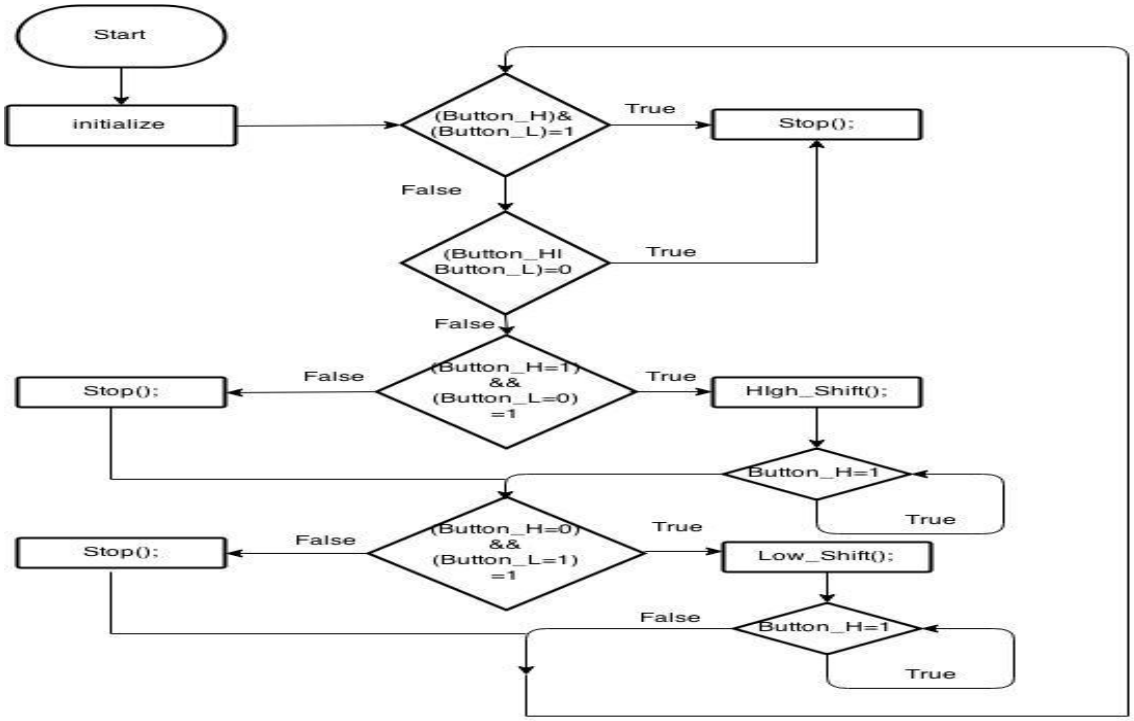

Fig 9 : Algorithm for the governing system

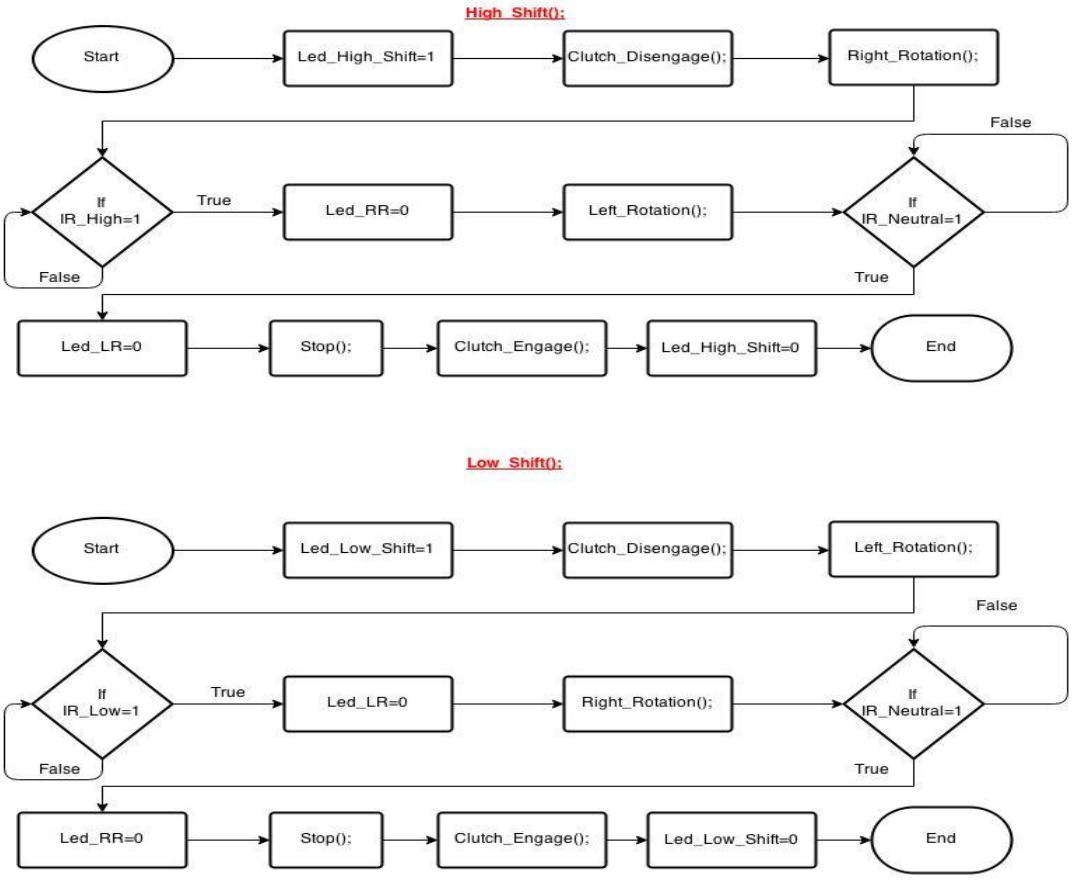

Fig 10 : Algorithm for high and low shifts of gears

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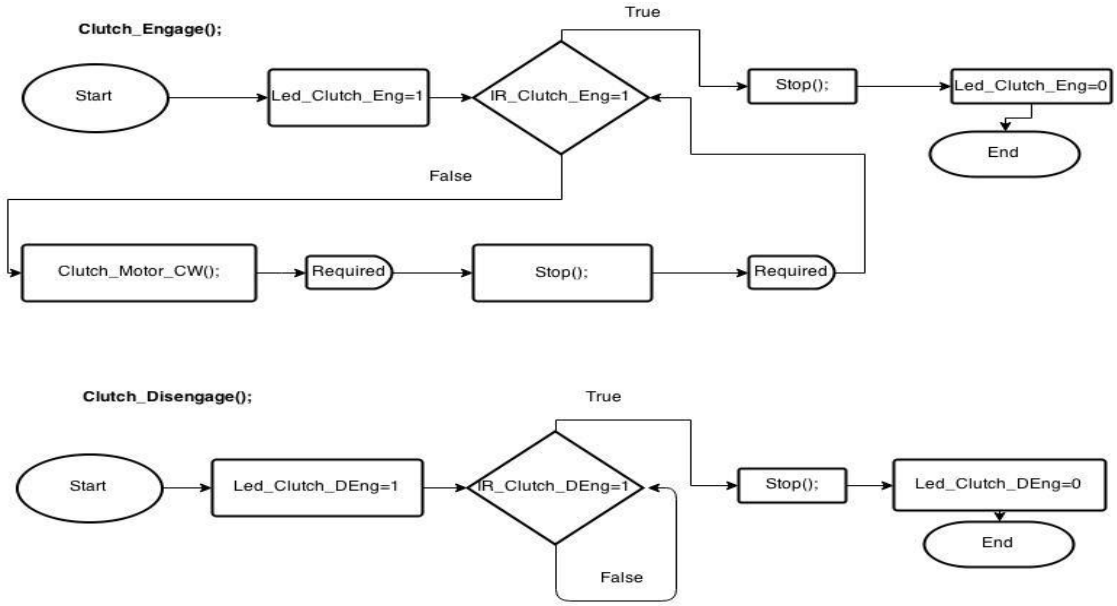

Fig 11: Algorithm for clutch engagement and disengagement

6. Future Scope:

This system could be used in student design competitions for easy and quick gear shifting. This system is easily applicable in upcoming motor bikes as a practical and economical feature. This system also holds scope to suit the needs of physically challenged drivers.

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