Sorting of Automatic Gear Transmission System Using Microcontroller

Divya Singh[1]
[1] Department of Mechanical Engineering
MIET, Greater Noida, India

Kaushal Pratap Singh[2]
[2] Department of Mechanical Engineering
Lovely Professional University, Punjab, India

Abstract— System consists of an improved control method that activates an electric motor to drive a torque-to-thrust converter for controlling the torque capacity of an electromagnetic clutch mechanism. The control utilizes a model-based feed-forward control in combination with a closed-loop position. The desired electromagnetic clutch torque capacity is characterized in terms of a desired motor speed (rpm) and position response as per motor position. The modeled speed and position in turn are used to create a feed-forward command and this command is combined with a feedback command based on actual position error.

Keywords— Thrust Converter, Clutch, Torque

I. Introduction

Automated gear transmission system is a perfect combination of electronic and mechanical science also known as Mechatronics. [1] We have used heavy mechanical equipments, electronic micro chip AT89C51, micro controller & discrete components. Heart of our system is strong powerful Electromagnetic clutch that has a high torque holding capacity.

In addition to that we have used one set of three gears in wheel shaft and other three gears with dc gear motor (engine) on power transmission shaft. We have fixed three Electromagnetic clutches in three transmission side gears and these clutches are controlled by microchip. When wheel shaft rotates, rpm counter give pulse to microchip and microchip decides gear clutching according to the speed. By default, our circuit attach to clutch-1. We control dc motor speed (power transmission shaft) with simple fan regulator.

II. Components Detail

A. Electromagnetic clutch

Electromagnetic clutch operates electrically, but transmit torque mechanically. Therefore, it is also referred to as electro-mechanical clutch. [2]

Construction- A horseshoe magnet has a north and South Pole. In an electromagnetic cultch, the north and South Pole is created by a coil shell and a wound coil. If a piece of carbon steel contacts both poles, a magnetic circuit is created. [3]

In a clutch when a power is applied, a magnetic field is created in the coil. This field (flux) overcomes an air gap between the clutch rotor and the armature. This magnetic attraction pulls the armature in contact with the rotor face as shown in figure 1. [2] The frictional contact which is being controlled by the strength of the magnetic field is what causes to start the rotational motion.

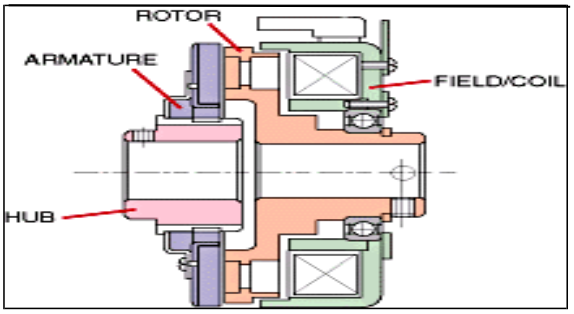

Fig.1 Rotor with Armature Working [2]

For many industrial clutches, friction material is used between the poles to decrease the wear rate and change the coefficient of friction. The coil shell is made with carbon steel that has a combination of good strength and good magnetic properties. Copper (sometimes aluminum) wire is used to create the coil, which is held in shell either by a bobbin or by some type of epoxy/adhesive. To increase the life of clutch, friction material is used between the poles to decrease the wear rate and change the coefficient of friction. [4]

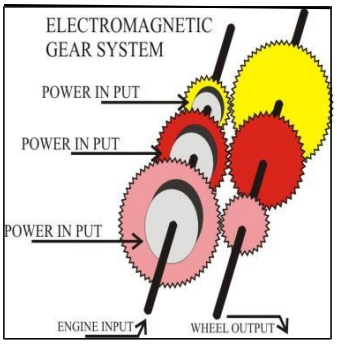

Fig.2 Electromagnetic clutch system

Basic Operation- The clutch has four main parts: field, rotor, armature, and hub. When voltage is applied, magnetic field is generated and the lines of flux pass into the rotor. The flux (magnetic attraction) pulls the armature in contact with the rotor (the armature is connected to the component that requires the acceleration) as shown in figure 2.

Slipping between the rotor face and the armature face continues until the input and output speed is the same (100% lockup). The actual time for this is quite short, between 1/200th of a second and 1 second. Disengagement is very simple. Once the field starts to degrade, flux falls rapidly and the armature separates. [3]

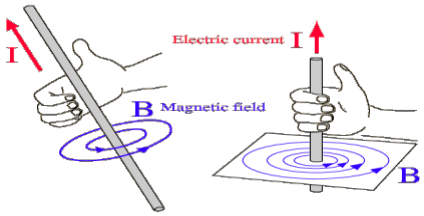

Fig.3 Voltage/Current and the Magnetic Field [4]

The magnetic field developed is based on "Right hand thumb rule" as shown in figure 3. The strength of the magnetic field can be changed by changing both wire size and by number of turns. Electro Magnetic clutch uses a copper wire coil (sometimes aluminum) to create a magnetic field. A constant power supply is ideal if accurate or maximum torque is required from a clutch. [4]

Engagement time- There is actually two engagement times to consider in an electromagnetic clutch. The first one is the time when coil develop a magnetic field, strong enough to pull an armature. Within this, there are two factors to consider. The first one is the amount of turns in a coil, which will determine the strength of a magnetic field and the second one is the air gap, which is the space between the armature and the rotor. [5]

Burnishing- Burnishing is the mating of opposing surfaces. It is the process of cycling the clutch to wear down those initial peaks, so that there is more surface contact between the mating faces to obtain maximum torque output. [5]

Torque- Burnishing can affect the torque but voltage/current is the main factor to determine the torque.

Over-Excitation- Over-excitation is used to achieve a faster response time. It is when a coil momentarily receives a higher voltage then its nominal rating. If voltage is increased three times, it gives around 1/3 faster response. [5]

Clutch Wear- Wear in the coil is usually due to heat developed in insulation of the coil. The heat can be caused by high ambient temperature, high cycle rates, slipping or applying too high voltage. Bushings can be used in some clutches that have low speed, low side loads or low operating hours. [6]

The main wear in electromagnetic clutches occurs on the faces of the mating surfaces. Every time a clutch is engaged during rotation, a certain amount of energy is transferred as heat. The transfer that occurs during rotation wears both the armature and the opposing contact surface. [6]

Environment / Contamination- Wear in clutch create wear particles. So in these applications the clutch should be enclosed to prevent the particles from contaminating the other surfaces around it. [6]

B. DC Motors

DC motor has a rotating armature in the form of an electromagnet as shown in figure 4. A rotary switch called a commutator reverses the direction of the electric current twice every cycle, to flow through the armature so that the poles of the electromagnet push and pull against the permanent magnets on the outside of the motor. As the poles of the armature passes the poles of the permanent magnets, the commutator reverses the polarity of the armature electromagnet. During that instant of switching polarity, inertia keeps the motor going in the proper direction. [7]

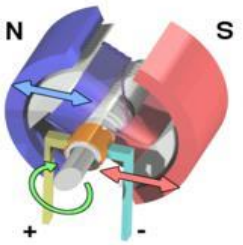

Fig.4 DC Motors [7]

C. Bearings

Bearings typically have to deal with two kinds of loading, radial and thrust as shown in figure 5.

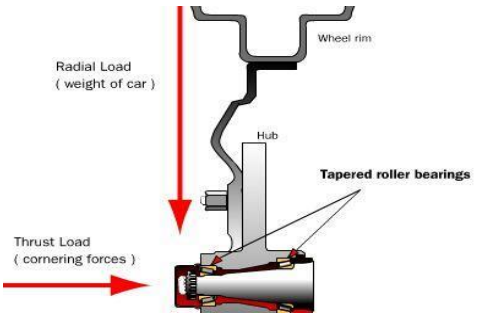

Fig.5 Bearings in a car wheel are subject to both thrust and radial loads.

The bearing above is like the one in the hub of the car wheel. This bearing has to support both a radial and thrust load. The radial load comes from the weight of the car and the thrust load comes when vehicle go around a turn. [8]

III.ELECTRONIC COMPONENTS DETAIL

A. *Microcontroller*– Microcontroller functions as a processing or controlling unit.

Features

- High Integration of Functionality
- Field Programmability and Flexibility
- Easy to Use

B. Microcontroller (AT89C51)-

8051 microcontroller as shown in figure 6 has 128 bytes of ram, 4k bytes of on-chip ROM, two timers, one serial port, and four ports (each 8-bits wide) all on a single chip. The 8051 is an 8-bit processor i.e. the CPU can work on only 8 bits of data at a time. The fixed amount of on-chip ROM, ram, and number of I/O ports in microcontroller makes them ideal for many applications in which cost and space are critical. The on-chip flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with flash on a monolithic chip, the AT89C51 is a powerful microcomputer, which provides a highly flexible and cost-effective solution to many embedded control applications.[9]

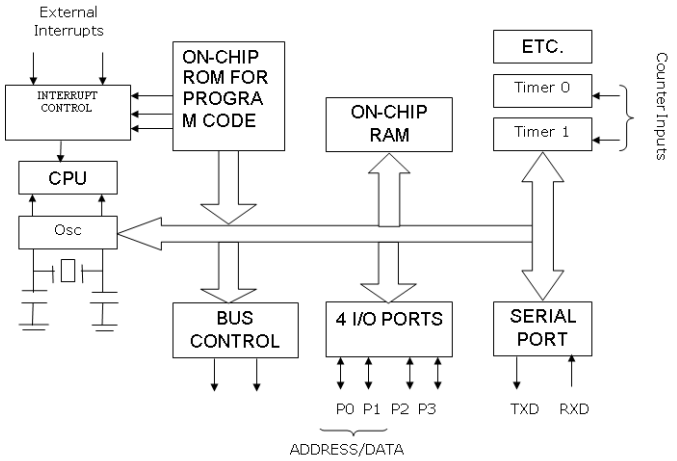

Fig.6 Microcontroller (AT89C51) [9]

Pin Description

Pin configuration is shown below in figure 7.

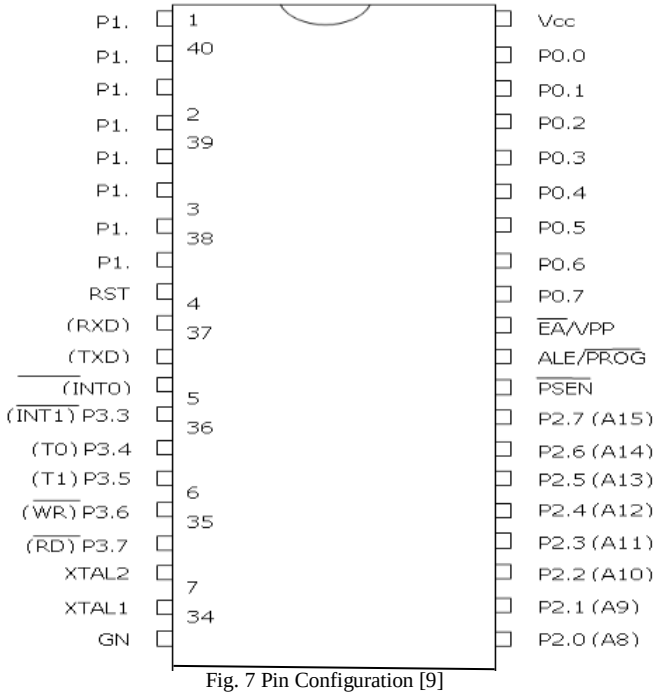

Fig. 7 Pin Configuration [9]

VCC *- Supply voltage.*

GND - Ground.

Port 0 - Port 0 is an 8-bit open-drain bi-directional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance inputs.

Port 0 also receives the code bytes during Flash programming and output the code bytes during program verification. External pull-ups are required during program verification. [9]

Port 1 - Port 1 is an 8-bit bi-directional I/O port with internal pull-ups.

The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins they are pulled high by the internal pull-ups and can be used as inputs. Port 1 also receives the low-order address bytes during Flash programming and verification. [10]

Port 2 - Port 2 is an 8-bit bi-directional I/O port with internal pull-ups.

The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins they are pulled high by the internal pull-ups and can be used as inputs. Port 2 emits the high-order address byte which was fetched by external program memory and during access to external data memory that uses 16-bit addresses (MOVX @ DPTR). During access to external data memory that uses 8-bit addresses (MOVX @ RI), Port 2 emits the contents of the P2 Special Function Register. [9]

Port 3 - Port 3 is an 8-bit bi-directional I/O port with internal pull-ups.

The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups. Port 3 also serves the functions of various special features of the AT89C51 as listed below:

RST - Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

ALE/PROG - Address Latch. Enable output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming.

P3rnal Data Memory. If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

PORT PIN	ALTERNATE FUNCTIONS
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	INT0 (external interrupt 0)
P3.3	INT1 (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	WR (external data memory write strobe)
P3.7	RD (external data memory read strobe)

PSEN - Program Store Enable is the read strobe to external program memory. When the AT89C51 is executing code from external program memory, PSEN is activated twice during each machine cycle except that two PSEN activations are skipped during each access to external data memory.[10]

EA/VPP - External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. However, if lock bit 1 is programmed EA will be internally latched on reset.
EA should be strapped to VCC for internal program executions. This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming for parts that require 12-volt VPP.
XTAL1 - Input to the inverting oscillator amplifier and input to the internal clock operating circuit.
XTAL2 - Output from the inverting oscillator amplifier. [9]

B. The 8051 Register

Register Banks in the 8051-

The 32 bytes of RAM which is set aside for the register banks and stack is divided into 4 banks of registers in which each bank has 8 registers, R0 – R7. RAM locations from 0 to 7 are set aside for bank R0 – R7. R0 is RAM location 0, R1 is RAM location 1, R2 is location 2, and so on, until memory location 7 which belongs to R7 of bank 0. The second bank of registers R0 – R7 starts at RAM location 08 and goes to location 0FH. The third bank of R0 – R7 starts at memory location 10H and goes to location 17H; and finally RAMS locations 18H to 1FH are set aside for the fourth bank of R0 – R7. The following tables show how the 32 bytes are allocated into 4 banks: [10]

Bank 0

R7	7
R6	6
R5	5
R4	4
R3	3
R2	2
R1	1
R0	0

Bank 1

R7	7
R6	6
R5	5
R4	4
R3	3
R2	2
R1	1
R0	0

Bank 2

R7	7
R6	6
R5	5
R4	4
R3	3
R2	2
R1	1
R0	0

Bank 3

R7	7
R6	6
R5	5
R4	4
R3	3
R2	2
R1	1
R0	0

STACK IN THE 8051-

The stack is a section of RAM used by CPU to store information temporarily. This information could be data or an address. The CPU needs this storage area because there are only limited numbers of registers. The register used to access the stack is called the SP (stack pointer) register. The stack pointer in the 8051 is only 8 bits wide i.e. it can take values of 00 to FFH. When the 8051 is powered up, the SP register contains value 07 which implies that RAM location 08 is the first location being used for the stack by the 8051. The storing of a CPU register in the stack is called a PUSH, and loading the contents of the stack back into a CPU register is called a POP. In other words, a register is pushed onto the stack to save it and popped off the stack to retrieve it. [11]

D. POWER SUPPLY

Most of the digital circuit operates on 5-volt DC supply which is obtained by the following circuit. The power supply circuit consists of a step down transformer, bridge rectifier and 7805 voltage regulator IC as shown in figure 8.

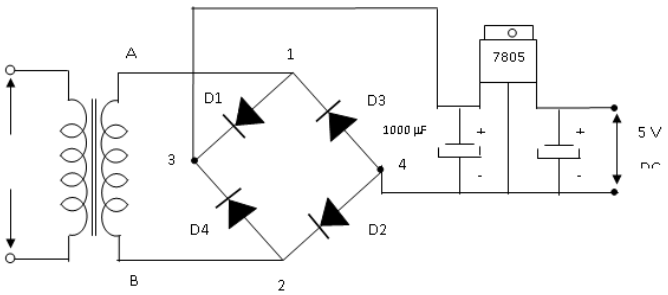

Fig.8 Power Supply

OPERATION: During the positive half cycle of the input supply, the upper end A of the transformer secondary becomes positive with respect to its lower point B. This makes Point1 of bridge positive with respect to point2. The diode D1 & D2 become forward biased and D3 & D4 become reverse biased. As a result, a current starts flowing from point1, through D1 load and D2 to the negative end. During negative half cycle, the point2 becomes positive with respect to point1. Diodes D1 & D2 now become reverse biased. Thus a current flow from point 2 to point1. [12]

E. TRANSFORMER:

Transformers play an important role having two or more windings usually wrapped around a common core made from laminated iron sheets. It has two coils named primary & secondary. For power supply we use step down transformer. We apply 220V AC on the primary of step down transformer. This transformer steps down this voltage to 9V AC. We give this 9 V AC to rectifier circuit, which convert it to 5V DC. [12]

F. REGULATOR: 7805 IC is used as regulator in 5V power supply. In 7805, Pin no.1 is input pin through which non-regulated signal is applied. Pin no.3 is grounded and the regulated output is taken from Pin no.2 as shown in figure 9. [13]

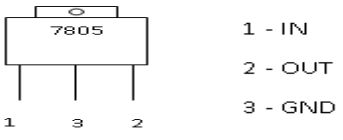

Fig. 9 Regulator

G. RELAYS

It is often desirable or essential to isolate one circuit electrically from another, while still allowing the first circuit to control the second. One simple method of providing electrical isolation between two circuits is to place a relay between them, as shown in the circuit diagram of figure 10. A relay consists of a coil that may be energized by the low-voltage circuit and one or more sets of switch contacts, which may be connected to the high-voltage circuit. [13]

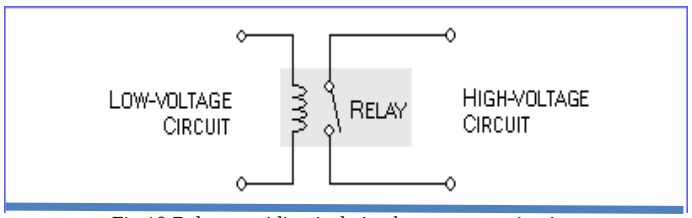

Fig.10 Relay providing isolation between two circuits

In figure 11 (a) the relay is off. The metal arm is at its rest position, so there is contact between the Normally Closed (N.C.) switch contact and the 'common' switch contact. If a current is passed through the coil, the resulting magnetic field attracts the metal arm and now contact is between the Normally Open (N.O.) switch contact and the common switch contact, as shown in figure 11 (b).[13]

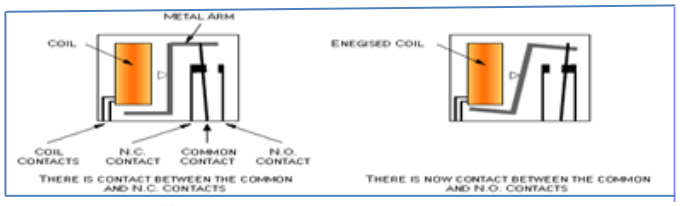

Fig 11 (a) Relay off Fig.11 (b) Relay on

H. CAPACITORS

It is an electronic component whose function is to accumulate and release charge when needed. Capacitors are of two types: - (1) fixed type like ceramic, polyester, electrolytic capacitors- these names refer to the material from which they are made. (2) Variable type like gang condenser. In fixed type capacitors, it has two leads and its value is written over its body and variable type has three leads. Unit of measurement of a capacitor is farad denoted by the symbol F. In case of electrolytic capacitors, its two terminal are marked as (-) and (+) so we can easily check while using it in the circuit. [14]

I. RESISTANCE

Resistance is the opposition of a material to the current. It is measured in Ohms. To control the electron flow (current) in a predictable manner, we use resistors as shown in figure 12. Electronic circuits use calibrated lumped resistance to control the flow of current.

Broadly speaking, resistor can be divided into two groups viz. fixed & adjustable (variable) resistors. In fixed resistors, the value is fixed & cannot be varied. In variable resistors, the resistance value can be varied by an adjuster knob. It can be divided into (a) Carbon composition (b) Wire wound (c) and Special type. The most common type of resistors used in our system is carbon type.[14]

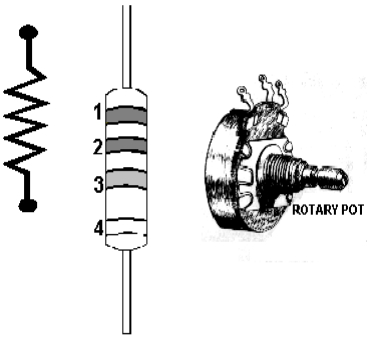

Fig.12 Resistors

J. TRANSISTOR

The name transistor derived from „transfer resistors" indicating a solid state Semiconductor device. In addition to conductor and insulators, there is a third class of material that exhibits proportion of both. Under some conditions, it acts as an insulator, and under other conditions it"s a conductor.
This phenomenon is called Semi-conducting and allows a variable control over electron flow. So, the transistor is semi conductor device used in electronics for amplitude.
Transistor has three terminals, one is the collector, one is the base and other is the emitter, (each lead must be connected in the circuit correctly and only then the transistor will function). Electrons are emitted via one terminal and collected on another terminal, while the third terminal acts as a control element. Each transistor has a number marked on its body. Every number has its own specifications. There are mainly two types of transistor (i) NPN & (ii) PNP.[14]

IV. WORKING

Working of the system is depicted with block diagram in figure 13 and through circuit diagram as shown in figure 14.

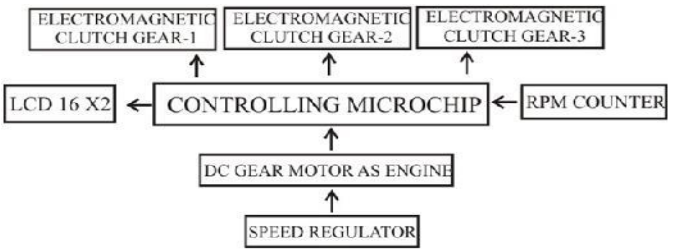

Fig.13 Block diagram of Working Mechanism

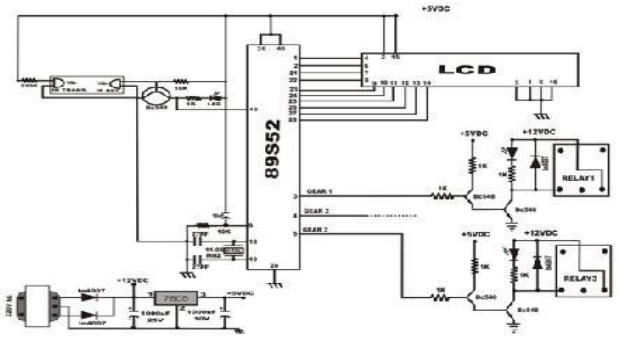

Fig.14 Electronic Circuit

Components requirement-
Electromagnetic clutch, Bearing, Wheel, Gear and chain, Dc motor, wooden frame, Plastic gear, Iron shaft, Transformer.

Electronic components-
IR Sensors, Controlling ICs and Switches

CONCLUSION
System deals with an improved control method that activates an electric motor to drive a torque-to-thrust converter for controlling the torque capacity of an electromagnetic clutch mechanism.

REFERENCES

[1] Abhishek Borse, Ajinkya Deshmukh, "Automatic Gear Transmission System," International Journal of Advanced Technology in Engineering and Science, Vol. 4, pp. 104-110, 02 February 2016.
[2] Sachithanandam P, Meikandaan T.P., Srividya T., "Steel framed multi storey residential building analysis and design," International Journal of Applied Engineering Research, V-9, pp. 5527-5529, 2014.
[3] Flemming, Frank, Shapiro, Jessica (ed.). "Basic of Electromagnetic
Cluthes and Brakes ," Machine Design, pp. 57–58.
[4] Watson, George, "PHYS345 Introduction to Right Hand Rule", University of Delaware.
[5] https://www.wikiwand.com/en/Frictionplate_electromagnetic_couplings.
[6] Dariusz Grzelczyk, Jan Awrejcewicz, "Wear Processes in a Mechanical Friction Clutch: Theoretical, Numerical, and Experimental Studies," Mathematical problem in Engineering, Hindawi Publishing Corporation, Vol.
2015, 28pages, 2015.
[7] Edvard, https://electrical-engineering-portal.com/basics-of-dc-motors- for-electrical-engineers-beginners, June 15 2015.
[8] Chetan P. Chaudhari, Bhushan B. Thakare, Saurabh R. Patil, Shrikant U., Gunjal, "A Study of Bearing and its Types, " International Journal of advance Research,Vol-4,pp. 1674-1681, March 2015.
[9] http://ww1.microchip.com/downloads/en/DeviceDoc/doc0265.pdf.
[10] Kenneth. J Ayala, The 8051 Microcontroller Architecture, Programming and Applications, West Publication Company, 1991.
[11] **https://www.elprocus.com/stack-memory-allocation-and-register-set- in-8051-microcontroller/**
[12] D P Kothari, T J Nagrath, Electric Machines, Fourth Edition.
[13] Md. Murshadul Hoque, "Design, implementation and performance study of programmable automatic voltage regulator," Journal of Electrical System, pp. 472-483, 2014.
[14] H.C Verma, Concepts of Physics, Vol.2, Bharati Bhawan publishers and distributors, 2019-2020.