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A New Approach of Breaking Technique for Instant Stopping of Dc Motor in Modern Automation

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Abstract— **DC geared or non-geared motors are the most commonly and widely used motors in robotics and various other applications due to their low cost easy mode of usage.**

DC motors have one major drawback i.e. they have very high inertia due to which they do not stop immediately even after supply is cut-off, rather their speed decreases gradually and then they stop. This makes them very inaccurate at the time of stopping.

For example: Let say a robotic arm employs a dc motor for its movement and we have to move it to 90 degrees downward. When we cut off the supply at 90 degrees the motor does not stops there, it stops after moving to 120 degrees or more depending upon the inertia, torque and load on the motor.

This is a common problem in DC motors and needs to be rectified. So, to rectify this problem we have designed a circuit. This circuit will reduce the problem of inertia in DC motors to a great extent. This circuit can be used in two different ways with some minor variations, one for autonomous control and other for manual control

Keywords- DC motor, instant stopping, microcontroller, robotic automation;

I. Introduction

If electrical energy is supplied to a conductor lying perpendicular to a magnetic field, the interaction of current flowing in the conductor and the magnetic field will produce mechanical force (and therefore, mechanical energy).There are two conditions which are necessary to produce a force on the conductor. The conductor must be carrying current, and must be within a magnetic field. When these two conditions exist, a force will be applied to the conductor, which will attempt to move the conductor in a direction perpendicular to the magnetic field. This is the basic theory by which all DC motors operate.

The force exerted upon the conductor can be expressed as follows.

$$F = B\,i\,l$$

Where B is the density of the magnetic field, lis the length of conductor, and ithe value of current flowing in the conductor. The direction of motion can be found using Fleming's Left Hand Rule.

Fleming's Left Hand Rule

The first finger points in the direction of the magnetic field (first - field), which goes from the North Pole to the South Pole. The second finger points in the direction of the current in the wire (second - current). The thumb then points in the direction the wire is thrust or pushed while in the magnetic field (thumb - torque or thrust).

II. Principle of Operation

Consider a coil in a magnetic field of flux density B. When the two ends of the coil are connected across a DC voltage source, current I flows through it. A force is exerted on the coil as a result of the interaction of magnetic field and electric current. The force on the two sides of the coil is such that the coil starts to move in the direction of force.

Torque production in a DC motor

In an actual DC motor, several such coils are wound on the rotor, all of which experience force, resulting in rotation. The greater the current in the wire, or the greater the magnetic field, the faster the wire moves because of the greater force created.

At the same time this torque is being produced, the conductors are moving in a magnetic field. At different positions, the flux linked with it changes, which causes an emf to be induced. This voltage is in opposition to the voltage that causes current flow through the conductor and is referred to as a counter-voltage or back emf.

Induced voltage in the armature winding of DC motor

The value of current flowing through the armature is dependent upon the difference between the applied voltage and this counter-voltage. The current due to this counter-voltage tends to oppose the very cause for its production according to Lenz's law. It results in the rotor slowing down.

Torque Developed

The equation for torque developed in a DC motor can be derived as follows.

The force on one coil of wire $F = i\, l \times B$ Newton

Therefore the torque for a multi turn coil with an armature current of Ia:

T = K I a

Where the flux/pole in Webber, K is is a constant depending on coil geometry, and the current flowing in the armature winding.

Note: Torque T is a function of force and the distance, equation (2) lumps all the constant parameters (e.g. length, area and distance) in constant K.

The mechanical power generated is the product of the machine torque and the mechanical speed of rotation,

Or, Pm= Mt

It is interesting to note that the same DC machine can be used either as a motor or as a generator, by reversing the terminal connections.

Reversibility of a DC machine

Induced Counter-voltage (Back emf):

Due to the rotation of this coil in the magnetic field, the flux linked with it changes at different positions, which causes an emf to be induced as shown in figure).

The induced emf in a single coil, e = dc /dt

Since the flux linking the coil, c= Sin t

Induced voltage: e = Cos t

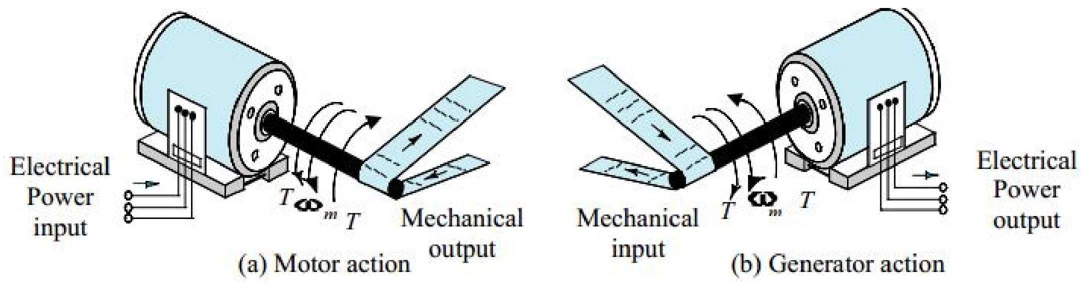


Figure 6: Reversability of a DC machine

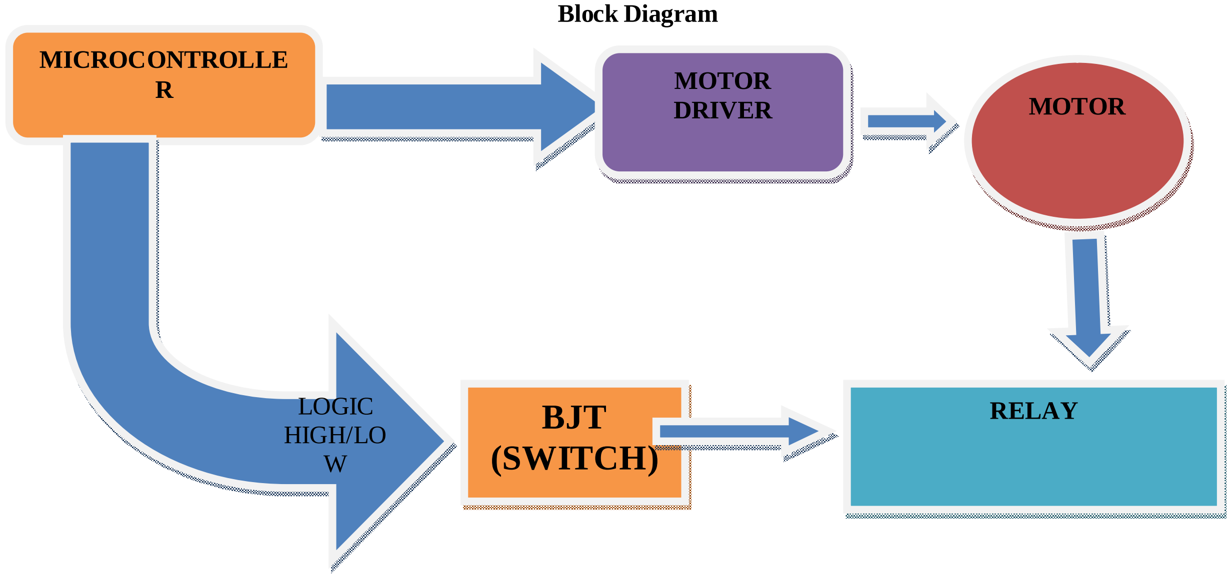
III. WORKING PRINCIPLE

While working with DC motors it was found out that they generate good amount of e.m.f when they are in motion. This generation of e.m.f could be controlled (minimized) and the motor can be stopped immediately. This would make the DC motors highly accurate.

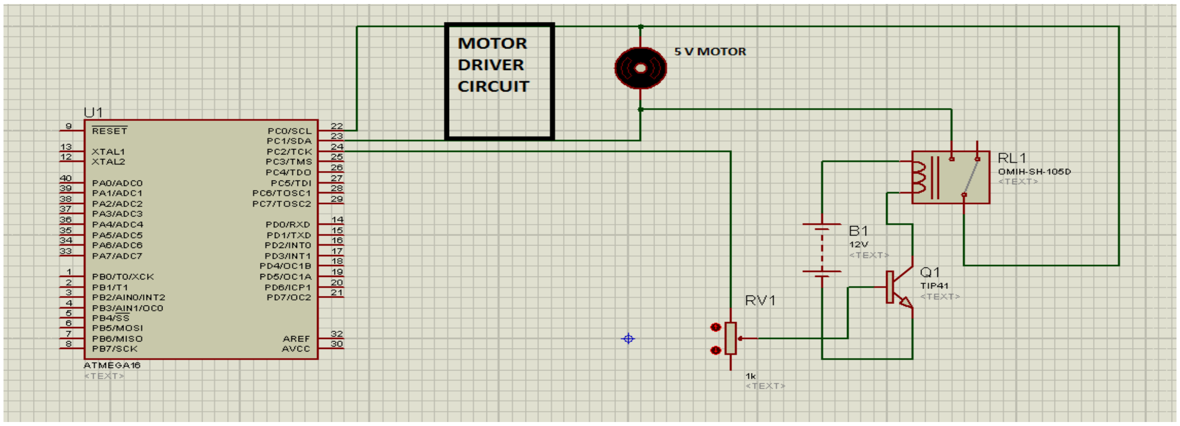
The detailed description and schematics of the circuit are given below with required components.

1. Microcontroller (ATMEGA 16)
2. Motor Driver (L298N)
3. BJT (TIP41)
4. Variable Resistance(1k)
5. Relay (SPST, 12 v)
6. DC Moto
7. ***AUTONOMOUS CONTROL***

Block Diagram



CIRCUIT DIGRAM



IV. Description

The working of this circuit is very simple. The motor is connected to the microcontroller through the motor driver and a BJT (npn) is used for switching the relay. Both the terminals of the motor are shorted when the relay is energized. When logic HIGH ("1") is given from the microcontroller to the base of BJT then the relay shorts the two terminals of the motor due to which the e.m.f generated by the motor during its motion is discharged against its own terminals and the motor stops instantly.

V. Caution

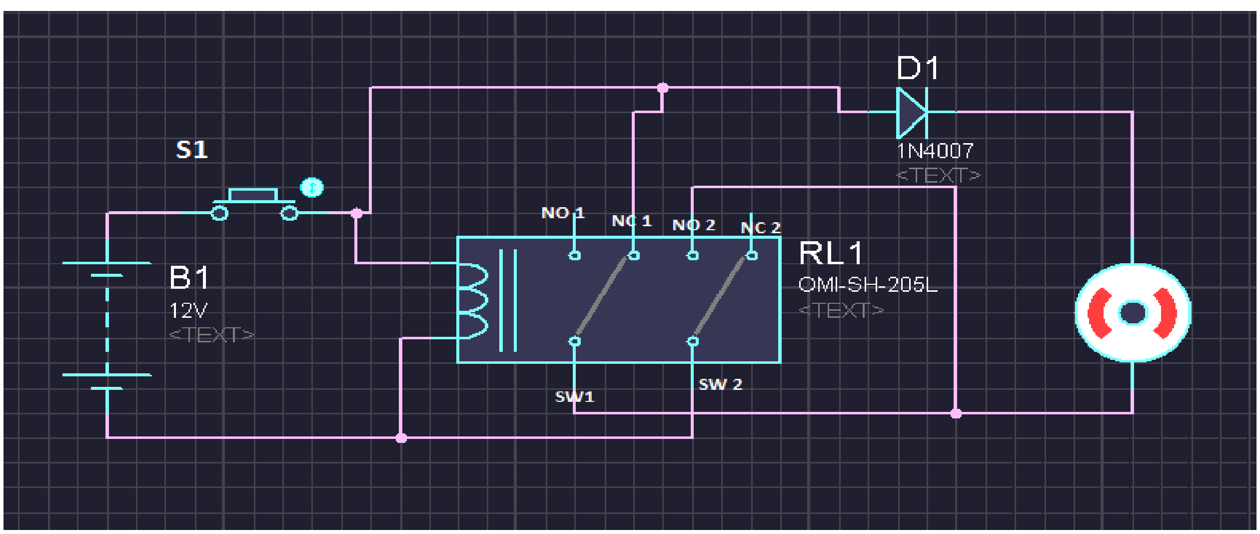
Before locking the motor the supply to the motor should be cut-off.

Before starting the motor again the lock must be released by giving logic low ("0") from the microcontroller at the base of BJT

VI. Manual Control

This circuit employs a DPDT relay which acts as two relays switching at the same time. One terminal of the motor is connected to the NO 2 pin of the relay. The other terminal of the motor is connected to the positive terminal of the battery through the diode in forward bias operation (i.e. it allows the current to flow to the motor but restricts the e.m.f from the motor). The negative terminal of the battery is connected to the SW2 pin of the relay. The two terminals of the motor are shorted using SW1 and NC1 pins of the relay. The motor and the relay are energized from the same source.

Initially, the terminals of the motor are shorted using SW1 and NC1 pins of the relay. When supply is given to the relay, SW1 and NC1 get open, and SW2 and NO2 gets connected. Now, the circuit gets completed and the motor starts running. Again, when the supply is cut off, the two terminals of the motor gets shorted and it stops instantly



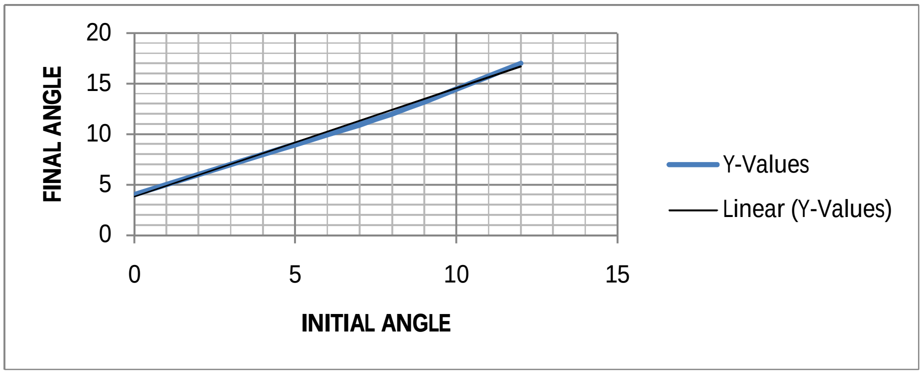
VII. PERFORMANCE ANALYSIS

OBSERVATION No.	MOTOR ON TIME (ms)	R.P.M	VOLTAGE (volts)	LOAD (grams)	INITIAL ANGLE (degrees)	FINAL ANGLE (degrees)	DEVIATION
1.	500	10	12	400	0	25	25
2.	500	10	12	400	25	81	56
3.	500	10	12	400	81	159	78
4.	500	10	12	400	159	180	21

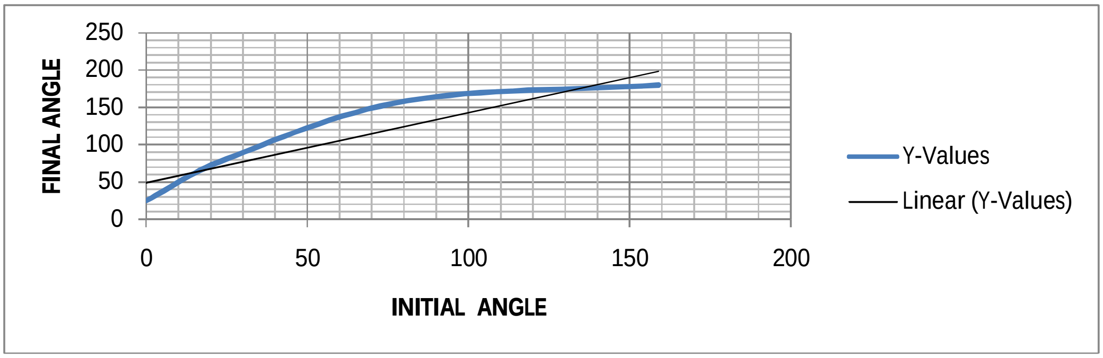
OBSERVATION No.	MOTOR ON TIME (ms)	R.P.M	VOLTAGE (volts)	LOAD (grams)	INITIAL ANGLE (degrees)	FINAL ANGLE (degrees)	DEVIATION
1.	500	10	12	400	0	4	4
2.	500	10	12	400	4	8	4
3.	500	10	12	400	8	12	4
4.	500	10	12	400	12	17	5

Without stopping &With stopping mechanism

With stopping mechanism



Without Stopping mechanism



VIII. CONCLUSION

From the above performance analysis we can conclude that after applying this mechanism the accuracy and precision of the DC motor are improved to a great extent. After applying this mechanism the motor shows almost linear behavior.

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