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FORWARD AND REVERSE CONTROL OF DC MOTOR USING PROXIMITY SENSOR (LIMIT SWITCH)

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Abstract: **In the proposed paper, we have a study of application of Boolean algebra to control circuits in electrical machines, specially transformers. Here, various types of relays have been described. Control schemes have been presented along with their operations. Boolean logic use has been successfully presented in the proposed paper.**

Keywords: ***Control transformers, Relays, Switches, Boolean logic.***

I. INTRODUCTION

Machine control design is a unique area of engineering that requires the knowledge of certain specific and unique diagramming techniques called ladder diagramming. Although there are similarities between control diagrams and electronic diagrams, many of the component symbols and layout formats are different. This chapter provides a study of the fundamentals of developing, drawing and understanding ladder diagrams. We will begin with a description of some of the fundamental components used in ladder diagrams. The basic symbols will then be used in a study of boolean logic as applied to relay diagrams. More complicated circuits will then be discussed.

BLOCK DIAGRAM

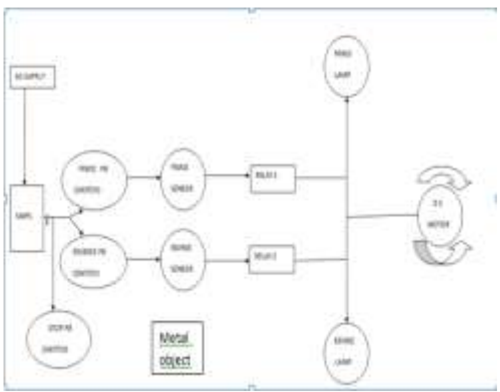

Figure1: Block Diagram of Controlling DC

Motor Using Proximity Sensor and Relay Logic

II. HARDWARE REQUIREMENTS

PUSH BUTTON:

The most common switch is the pushbutton. It is also the one that needs the least description because it is widely used in automotive and electronic equipment applications. There are two types of pushbutton, the momentary and maintained. The momentary pushbutton switch is activated when the button is pressed, and deactivated when the button is released. The deactivation is done using an internal spring. The maintained pushbutton activates when pressed, but remains activated when it is released. Then to deactivate it, it must be pressed a second time. For this reason, this type of switch is sometimes called a push-push switch. The on/off switches on most desktop computers and laboratory oscilloscopes are maintained pushbuttons.

MAINTAINED PUSHBUTTON

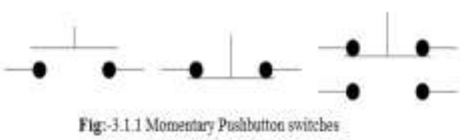

Figure2: Schematic symbols for a normally open pushbutton (left) and a normally closed pushbutton (center)

The symbol on the right of Figure-2 is a single pushbutton with both N/O and N/C contacts. There is no internal electrical connection between different contact pairs on the same switch.

Figure3: Momentary Pushbutton

The momentary push-button switch is a type of biased switch. The most common type is a "push-to-make" (or normally-open or NO) switch, which makes contact when the button is pressed and breaks when the button is released.

MAINTAINED PUSHBUTTON

Figure4: Maintained Pushbuttons

A type of switch usually in the form of a push button that is only engaged while it is being depressed, as opposed to a typical “on/off” switch, which latches in its set position. Momentary switches may be normally open or normally closed.

PROXIMITY SENSORS

Proximity sensors are discrete sensors that sense when an object has come near to the sensor face. There are four fundamental types of proximity sensors, the inductive

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proximity sensor, the capacitive proximity sensor, the ultrasonic proximity sensor, and the optical proximity sensor. In order to properly specify and apply proximity sensors, it is important to understand how they operate and to which applications each is best suited.

INDUCTIVE PROXIMITY SENSOR

As with all proximity sensors, inductive proximity sensors are available in various sizes and shapes as shown in Figure 3.2.1 As the name implies, inductive proximity sensors operate on the principle that the inductance of a coil and the power losses in the coil vary as a metallic (or conductive) object is passed near to it. Because of this operating principle, inductive proximity sensors are only used for sensing metal objects. They will not work with non-metallic materials.

To understand how inductive proximity sensors operate, consider the cutaway block diagram shown in Figure-5 Mounted just inside the face of the sensor (on the left end) is a coil which is part of the tuned circuit of an oscillator.

When the oscillator operates, there is an alternating magnetic field (called a sensing field) produced by the coil. This magnetic field radiates through the face of the sensor (which is non-metallic).

The oscillator circuit is tuned such that as long as the sensing field senses non-metallic material (such as air) it will continue to oscillate, it will trigger the trigger circuit, and the output switching device (which inverts the output of the trigger circuit) will be off.

When a metallic object (steel, iron, aluminum, tin, copper, etc.) comes near to the face of the sensor, as shown in Figure-4, the alternating magnetic field in the target produces circulating eddy currents inside the material. To the oscillator, these eddy currents are a power loss. As the target moves nearer, the eddy current loss increases which loads the output of oscillator. This loading effect causes the output amplitude of the oscillator to decrease

As long as the oscillator amplitude does not drop below the threshold level of the trigger circuit, the output of the sensor will remain off. However, as shown in Figure-5, if the target object moves closer to the face of the sensor, the eddy current loading will cause the oscillator to stall (cease to oscillate). When this happens, the trigger circuit senses the loss of oscillator output and causes the output switching device to switch "on"

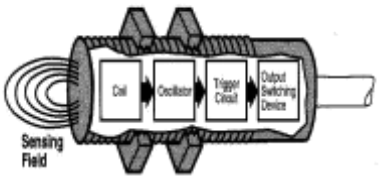

Figure5: Inductive proximity sensor

The sensing range of a proximity sensor is the maximum distance the target object may be from the face of the sensor in order for the sensor to detect it. One parameter affecting the sensing range is the size (diameter) of the sensing coil in the sensor. Small diameter sensors (approximately ¼" in diameter) have typical sensing ranges in the area of 1mm, while large diameter sensors (approximately 3" in diameter) have sensing ranges in the order of 50mm or more. Additionally, since different metals have different values of resistivity (which limits the eddy currents) and permeability (which channels the magnetic field through the target), the type of metal being sensed will affect the sensing range.

Inductive proximity sensor manufacturers de rate their sensors based on different metals, with steel being the reference (i.e., having a de rating factor of 1.0). Some other approximate de rating factors are stainless steel: 0.85, aluminum: 0.40, brass: 0.40, and copper 0.30.

Inductive proximity sensors are available in both DC and AC powered models. Most require 3 electrical connections: ground, power, and output.

To illustrate some of the wide range of possible applications of inductive proximity sensors (sometimes called inductive prox), consider these uses:

By placing an inductive prox next to a gear, the prox can sense the passing gear teeth to give rotating speed information. This application is currently used as a speed feedback device in automotive cruise control systems where the prox is mounted in the transmission.

Inductive proxes can be mounted on access doors and panels of machines The PLC can be programmed to shut down the machine anytime any of these doors and access panels are opened.

Very large inductive proxes can be mounted in roadbeds to sense automobiles. This technique is currently used to operate traffic lights.

CHANGE OVER RELAYS:

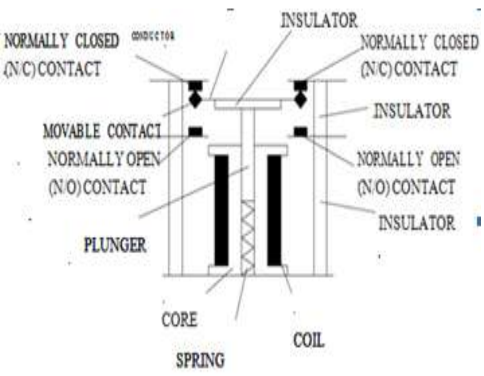

Figure6: Relay

Early electrical control systems were composed of mainly relays and switches. Switches are familiar devices, but relays may not be so familiar. Therefore, before continuing our discussion of machine control ladder diagramming, a brief discussion of relay fundamentals may be beneficial. A simplified drawing of a relay with one contact set is show in Figure-6.

It is important to remember that many of the schematic symbols used in electrical diagrams are different than the symbols for the same types of components in electronic diagrams.

Relays can range in size from extremely small reed relays in 14 pin DIP integrated circuit-style packages capable of switching a few tenths of an ampere at less than 100 volts to large contactors the size of a room capable of switching thousands of amperes at thousands of volts. However, for electrical machine diagrams, the schematic symbol for a relay is the same regardless of the relay's size.

Figure7: Parts of Relay

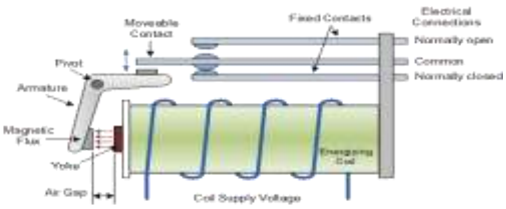

Figure8: Parts of Relay

DC MOTOR

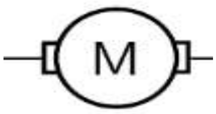

Figure9: Symbol of DC Motor

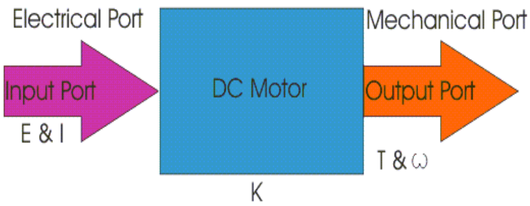

Figure10: DC Motor

Principle of DC Motor:

This DC or direct current motor works on the principle, when a current carrying conductor is placed in a magnetic field, it experiences a torque and has a tendency to move.

This is known as motoring action. If the direction of current in the wire is reversed, the direction of rotation also reverses. When magnetic field and electric field interact they produce a mechanical force, and based on that the working principle of DC motor is established.

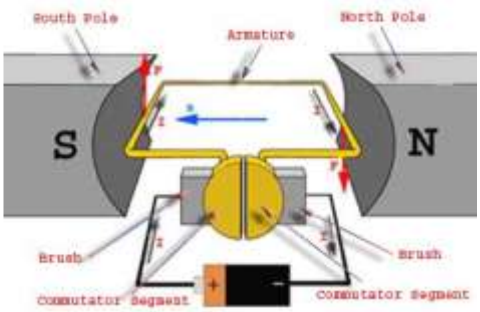

Figure11: Constructional Features of DC Motor

The very basic Construction of DC Motor contains a current carrying armature which is connected to the supply end through commutator segments and brushes it is placed within the north south poles of a permanent or an electro-magnet as shown in the diagram below.

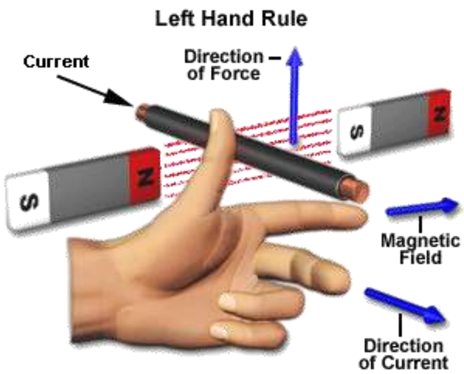

Figure12: Fleming's Left Hand Rule

Fleming's left hand rule says that if we extend the index finger, middle finger and thumb of our left hand in such a way that the current carrying conductor is placed in a Magnetic Field (represented by the index finger) is perpendicular to the direction of Current (represented by the middle finger),

then the conductor experiences a force in the direction (represented by the thumb) mutually perpendicular to both the direction of field and the current in the conductor.

For clear understanding the principle of DC motor we have to determine the magnitude of the force, by considering the diagram below. We know that when an infinitely small charge dq is made to flow at a velocity 'v' under the influence of an electric field E, and a magnetic field B, then the Lorentz Force LF experienced by the charge is given by:-

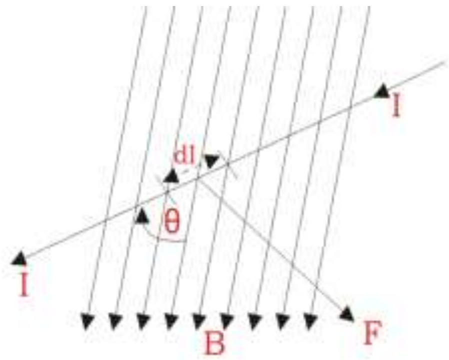

Figure13: Operation

$$dF = dq(E + vB)$$

For the operation of DC motor, considering E = 0

$$dF = dq \times v \times B$$

i.e. it's the cross product of DQ V and magnetic field B.

$$dF = dq\frac{dL}{dt} \times B \qquad \left[V = \frac{dL}{dt}\right]$$

Where dL is the length of the conductor carrying charge q.

$$dF = dq\frac{dL}{dt} \times B$$

$$or,\ dF = IdL \times B \qquad \left[Since,\ current\ I = \frac{dq}{dt}\right]$$

$$or,\ F = IL \times B = ILB\sin\theta$$

$$or,\ F = BIL\sin\theta$$

From the 1st diagram we can see that the construction of a DC motor is such that the direction of current through the armature conductor at all instance is perpendicular to the field. Hence the force acts on the armature conductor in the direction perpendicular to the both uniform field and current is constant.

$$i.e.\ \theta = 90^\circ$$

So if we take the current in the left hand side of the armature conductor to be I, and current at right hand side of the armature conductor to be − I, because they are flowing in the opposite direction with respect to each other. Then the force on the left hand side armature conductor,

$$F_i = BIL\sin 90^\circ = BIL$$

Similarly force on the right hand side conductor

$$F_r = B(-I)L\sin 90^\circ = -BIL$$

∴ we can see that at that position the force on either side is equal in magnitude but

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opposite in direction. And since the two conductors are separated by some distance w = width of the armature turn, the two opposite forces produces a rotational force or a torque that results in the rotation of the armature conductor. Now let's examine the expression of torque when the armature turn crate an angle of α with its initial position. The torque produced is given by,

$$Torque = (force,\ tangential\ to\ the\ d \ldots n) \times (distance)$$

$$or,\ \tau = F \cos\alpha \times w$$

$$or,\ \tau = BILw \cos\alpha$$

Where, α is the angle between the plane of the armature turn and the plane of reference or the initial position of the armature which is here along the direction of magnetic field. The presence of the term cos α in the torque equation very well signifies that unlike force the torque at all position is not the same. It in fact varies with the variation of the angle α. To explain the variation of torque and the principle behind rotation of the motor let us do a step wise analysis.

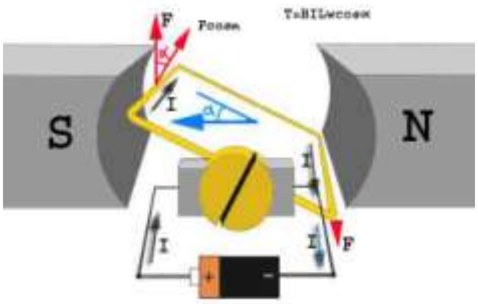

Figure14: Movement of Conductor

Step 1: Initially considering the armature is in its starting point or reference position where the angle α = 0.

$$\therefore\ \tau = BILw \times \cos 0° = BILw$$

Since, α = 0, the term cos α = 1, or the maximum value, hence torque at this position is maximum given by τ = BILw. This high starting torque helps in overcoming the initial inertia of rest of the armature and sets it into rotation.

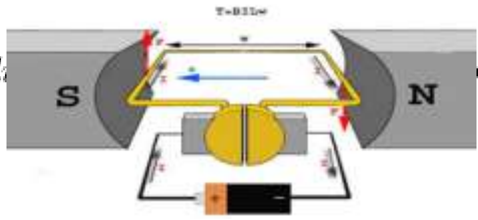

Figure15: Operation of DC Motor

Step 2: Once the armature is set in motion, the angle α between the actual position of the armature and its reference initial position goes on increasing in the path of its rotation until it becomes 90° from its initial position. Consequently the term cos α decreases and also the value of torque. The torque in this case is given by τ = BILwcosα which is less than BIL w when α is greater than 0°.

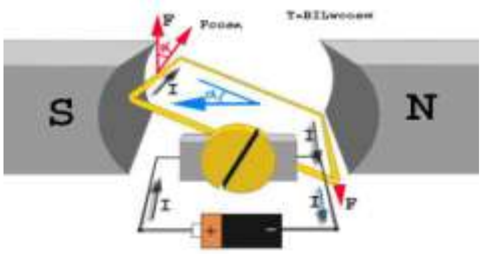

Figure16: Operation of DC Motor rotation

Step 3: In the path of the rotation of the armature a point is reached where the actual position of the rotor is exactly perpendicular to its initial position, i.e. α = 90°, and as a result the term cos α = 0. The torque acting on the conductor at this position is given by,

$$\therefore \tau = BIL\omega \times \cos 90^o = 0$$

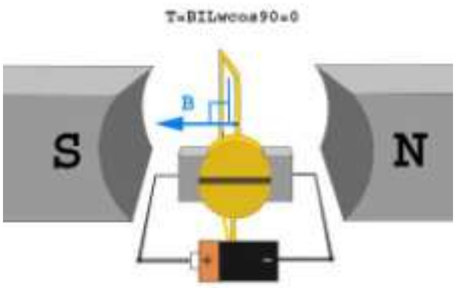

Figure17: Motor in 90 degrees

i.e. virtually no rotating torque acts on the armature at this instance. But still the armature does not come to a standstill, this is because of the fact that the operation of DC motor has been engineered in such a way that the inertia of motion at this point is just enough to overcome this point of null torque. Once the rotor crosses over this position the angle between the actual position of the armature and the initial plane again decreases and torque starts acting on it again.

INDICATOR LAMPS

Lamp all control panels include indicator lamps. They tell the operator when power is appoed to the machine and indicate the machine indictor are drawn as a circle with light rays extending on the diagonals as shown in Figure-17.

Although the light bulbs used in indicators are generally incandescent (white), they are usually covered with colored lenses. The colors are usually red, green, or amber, but other colors are also available. Red lamps are reserved for safety critical indicators (power is on, the machine is running, an access panel is open, or that a fault has occurred). Green usually indicates safe conditions (power to the motor is off, brakes are on, etc.). Amber indicates conditions that are important but not dangerous (fluid getting low, machine paused, machine warming up, etc.).

Figure18: Indicating Lamps

SMPS:

A switched mode power supply (switching-modepower supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic powersupply thatincorporate a switchingregulator to convert electrical power efficiently.

Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power), to DC loads such as a personal computer, converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. Ideally, a switched-mode power supply dissipates no power.

Figure19: External View of SMPS

Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

Figure20: Internal View of SMPS

CIRCUIT DIAGRAM

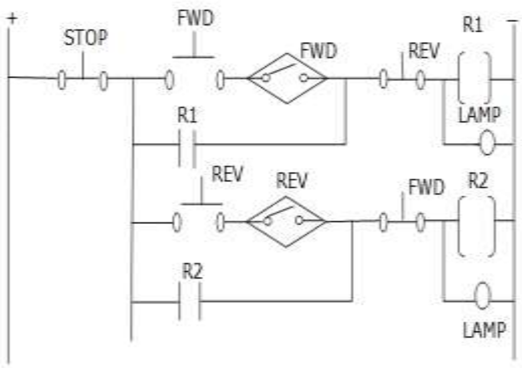

Figure21: Circuit Diagram

III. OPERATION

1. In this project we are going to control the DC Machine using proximity sensor and relay logic (limit switches).

2. Now a day's most of the conveyor belt required both forward and reverse direction

3. We are using 12 V DC power supply circuit to provide supply for DC Motor.

4. In this operation two loading points are there one is for forward loading point and another one is reverse loading point.

5. Two proximity sensors are required one is for forward direction and another is for reverse direction.

6. Whenever there is an metal object placed near the sensor by pressing the forward push button the forward sensor will sense the metal and motor will operate in forward direction and similarly in reverse direction we can control the direction of conveyor.

IV. APPLICATIONS

1. 100% Conveyor applicable.
2. Can Used in airports as luggage belt (conveyor).
3. Used in Automated Industrial Processes.
4. Used in Amusement Parks.
5. Car washes, Metal detector.
6. Also we can use in wind fan.

V. ADVANTAGES

1. Whenever we placed the material in front of sensor than only conveyor will on.
2. Controlling logic diagram is easy.
3. If any fault will occur relay will sense it.
4. Motor will not get damage if any short circuit happen relay will get damage by which protecting the motor and we can easily replace the relay.

VI. CONCLUSION

1. Relays control output circuits of a much higher power.
2. Safety is increased.
3. Protective relays are essential for keeping faults in the system isolated and keep equipment from being damaged.
4. Here we are obtaining the result as working of dc motor in both forward and in reverse direction
5. Major advantage of this research is only by sensing the materials it will work, It will save the electricity and manpower.

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