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Speed Control of Dc Motor Using PWM Technique

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Abstract- DC Motors are widely employed in industry for speed control and load characteristics because of their ease controllability, which results in effective and exact output. apidity Controlling. the speed of a dc motor is critical in many applications. To do this, we employed the PWM approach, which meets all of the requirements for dc motor speed control. Electronic components make up a PWM-based speed control system.

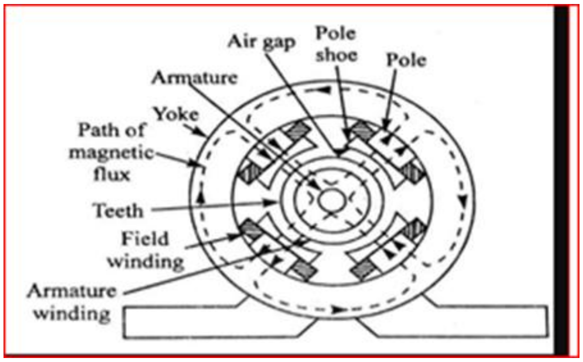
I. INTRODUCTION

Any rotary electrical motor that converts direct current electrical energy into mechanical energy is referred to as a DC motor. The most common varieties rely on magnetic fields to produce forces. Almost all DC motors contain an internal mechanism, either electromechanical or electronic, that changes the direction of current in a section of the motor on a regular basis.

Because they could be supplied by existing direct-current lighting power distribution networks, DC motors were the first type of motor to become widely employed. The speed of a DC motor can be varied across a large range by varying the supply voltage or adjusting the current intensity in the field windings. Tools, toys, and appliances all employ small DC motors. The universal motor can run on direct current. However, it is a little brushed motor that is utilized in portable power equipment and appliances. Larger DC motors are being employed in electric vehicle propulsion, elevator and hoist drives, and steel rolling mill drives. With the introduction of power electronics, it is now possible to replace DC motors with AC motors in a variety of applications.

II. THE PRINCIPLE OF WORKING & CONSTRUCTION OF DC MOTOR

A DC motor is a type of electric motor that converts electrical energy into mechanical energy. The DC motor's primary working concept is that whenever a current carrying conductor enters the magnetic field, it is subjected to a mechanical force. The magnitude of Fleming's left-hand rule determines the force's direction.



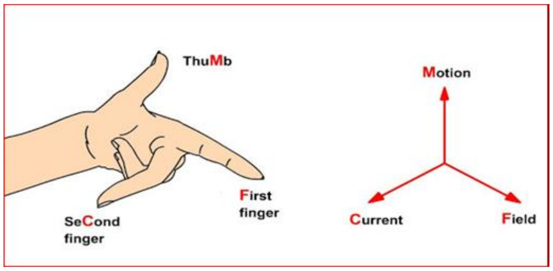
- Fleming's Left-Hand Rule:

If we stretch our left hand's first, second, and thumb perpendicular to each other, and the first finger represents the magnetic field, the second finger represents the current, and the thumb represents the force experienced by the current carrying conductor,

$F = BIL$ Newtons
Where,
B = magnetic flux density,
I = current and
L = length of the conductor within the magnetic field.

When a DC source is linked to an armature winding, an electric current is created in the winding. The magnetic field is created by permanent magnets or field winding (electromagnetism). According to the above-mentioned principle, current-carrying armature conductors are subjected to a force due to the magnetic field.

When a DC source is connected to an armature winding, the winding generates an electric current. Permanent magnets or field windings generate the magnetic field (electromagnetism). Current-carrying armature conductors are subjected to a force owing to the magnetic field, according to the above-mentioned principle.

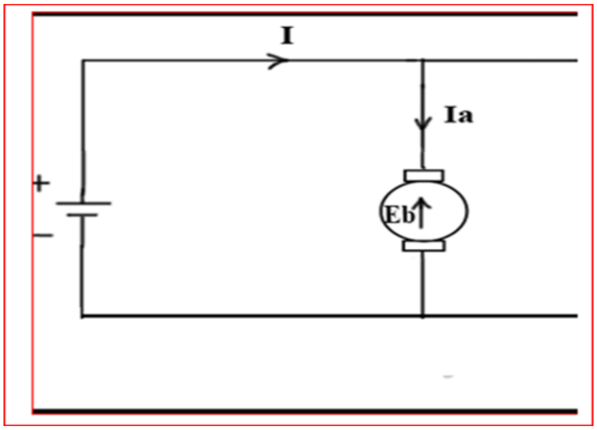


- Back- EMF of DC motor:

No energy conversion is possible until there is something to oppose it, according to the fundamental law of nature. This opposition is provided by magnetic drag in generators, but back emf is present in dc motors. A dc motor becomes self-regulating when the back emf is present.

When the armature of a motor rotates, the conductors cut the magnetic flux lines, causing an emf to induce in the armature conductors, according to Faraday's law of electromagnetic induction.

The induced emf is directed in the opposite direction as the armature current (Ia). The direction of the back emf and armature current is shown in the circuit diagram below.

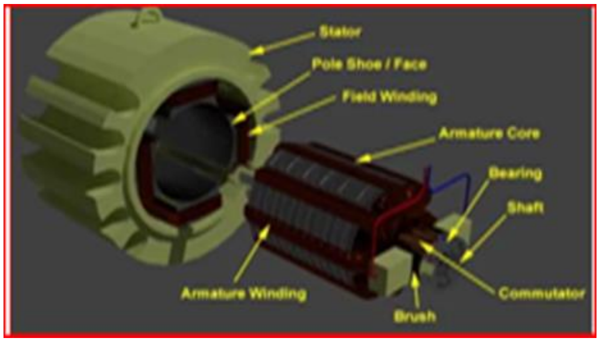


A DC motor is a device that converts direct current electrical energy into mechanical energy (find out more about DC motors).

A DC motor is constructed with:

- A Stator
- A Rotor
- A Yoke
- Poles
- Field windings
- Armature windings
- Commutator
- Brushes

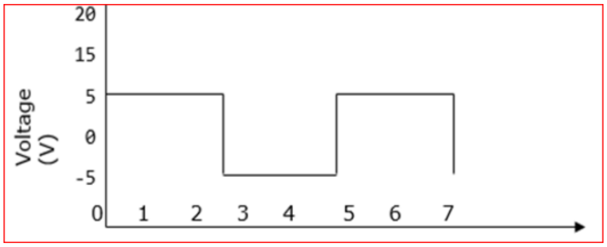
The field windings and supplies are housed in the stator, which is the static element of the DC machine. The revolving portion of a DC machine that causes mechanical rotations is called a rotor. The complete construction of a DC MOTOR is made up of all of these pieces combined together.



III. PULSE WIDTH MODULATION

PWM is a technique that is used to reduce the total harmonic distortion (THD) in a load current. It uses a pulse wave in rectangular/square form that results in a variable average waveform value f(t), after its pulse width has been modulated. T specifies the modulation time interval. As a result, the waveform average value is

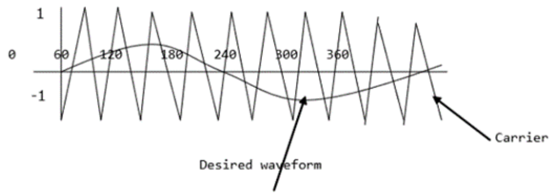
bar{y}=\frac{1}{T}\int_{0}^{T}f\left (t \right)dt



- Sinusoidal Pulse Width Modulation:

The switches in a simple source voltage inverter can be switched on and off as required. The switch is switched on and off once during each loop. As a consequence, the waveform is square. When the switch is turned on repeatedly, however, a harmonic profile with a better waveform is obtained.

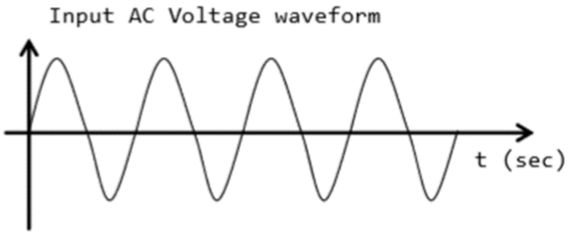
The sinusoidal PWM waveform is created by comparing the desired modulated waveform to a high-frequency triangular waveform. The resultant output voltage of the DC bus is either negative or positive, depending on whether the signal voltage is smaller or larger than that of the carrier waveform.

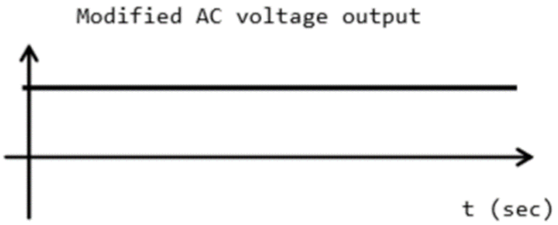


Am denotes the sinusoidal amplitude, while Ac denotes the carrier triangle. The modulating index m is equal to Am/Ac for sinusoidal PWM.

- Modified Sinusoidal Waveform PWM:

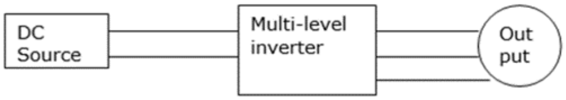
For power control and power factor optimization, a modified sinusoidal PWM waveform is used. The key idea is to change the PWM converter to transfer current delayed on the grid to the voltage grid. As a result, there is an increase in power production as well as a reduction in power factor.



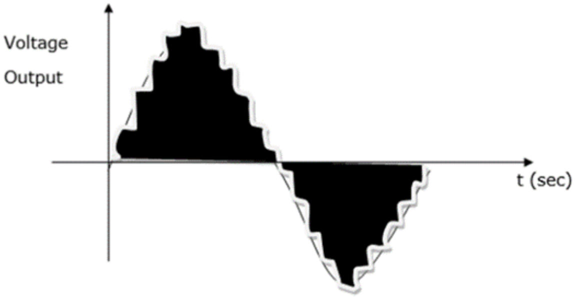


- Multiple PWM:

The multiple PWM has a number of outputs with different values, but the time period over which they are produced is the same for all of them. PWM-enabled inverters can operate at high voltage output.



The waveform below is a sinusoidal wave produced by a multiple PWM



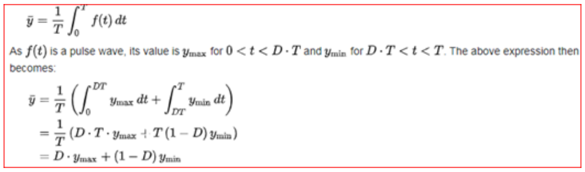
PWM (pulse width modulation) or PDM (pulse-duration modulation) is a technique for decreasing the average power produced by an electrical signal by splitting it up into discrete parts. By rapidly flipping the switch between supply and load on and off, the average value of voltage (and current) provided to the load can be regulated. The longer the switch is on relative to the time it is off, the better. The higher the total power delivered to the load, the better. It is one of the principal methods of decreasing the output of solar panels to that which can be used by a battery, along with maximum power point tracking (MPPT). 1st PWM is especially well suited for running inertial loads like motors, which are less influenced by discrete switching due to their inertia.

Depending on the load and application, the rate (or frequency) at which the power supply must switch can vary substantially. An electric stove, for example, must switch several times per minute; a lamp dimmer must switch 120 Hz; a motor drive must switch between a few kilohertz (kHz) and tens of kHz; and audio amplifiers and computer power supplies must switch far into the tens or hundreds of kHz. The key benefit of PWM is that it has a very low power loss in the switching devices. There is nearly no current when a switch is turned off, and there is almost no voltage drop across the switch when it is turned on and power is transferred to the load. Because power loss is the product of voltage and current, it is near to zero in both circumstances. PWM also works well with digital controls, which are more common these days.

Because of its on/off nature, the duty cycle can be readily set. PWM has also been utilized in communication systems, where the duty cycle is employed to transmit data over a communications channel. Many modern microcontrollers (MCUs) include PWM controllers that are exposed to external pins as peripheral devices that are controlled by software via internal programming Interfaces. These are extensively used in robotics and other applications to control direct current (DC) motors.

- Principle:

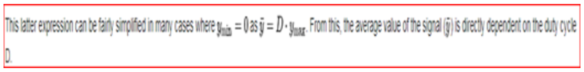
Pulse-width modulation employs a rectangular pulse wave with a modulated pulse width, resulting in a variation in the waveform's average value. The average value of a pulse waveform f(t) with time period T, low value y min, high value y max, and duty cycle D is given by



$$\bar{y} = \frac{1}{T}\int_0^T f(t)\,dt$$

As $f(t)$ is a pulse wave, its value is $y_{\max}$ for $0 < t < D \cdot T$ and $y_{\min}$ for $D \cdot T < t < T$. The above expression then becomes:

$$\begin{aligned}\bar{y} &= \frac{1}{T}\left(\int_0^{DT} y_{\max}\,dt + \int_{DT}^{T} y_{\min}\,dt\right)\\ &= \frac{1}{T}\left(D \cdot T \cdot y_{\max} + T(1-D)\,y_{\min}\right)\\ &= D \cdot y_{\max} + (1-D)\,y_{\min}\end{aligned}$$

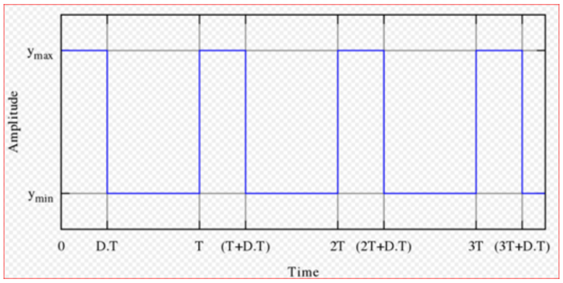


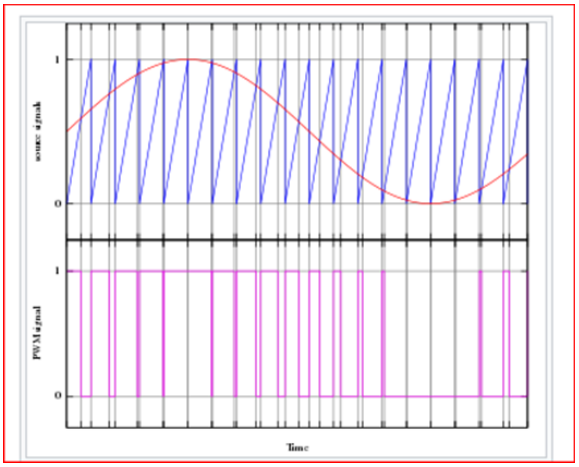
This latter expression can be fairly simplified in many cases where $y_{\min} = 0$ as $\bar{y} = D \cdot y_{\max}$. From this, the average value of the signal ($\bar{y}$) is directly dependent on the duty cycle D.

The intersective approach, which requires only a sawtooth or triangle waveform (easily made with a simple oscillator) and a comparator, is the simplest technique to generate a PWM signal. The PWM signal (magenta) is in the high state when the value of the reference signal (the red sine wave in figure 2) is greater than the modulation waveform (blue), and it is in the low state otherwise.

- Delta:

The output signal is integrated when delta modulation is used for PWM control, and the result is compared against limitations, which correspond to a Reference signal offset by a constant. The PWM signal changes when the integral of the output signal reaches one of the restrictions.



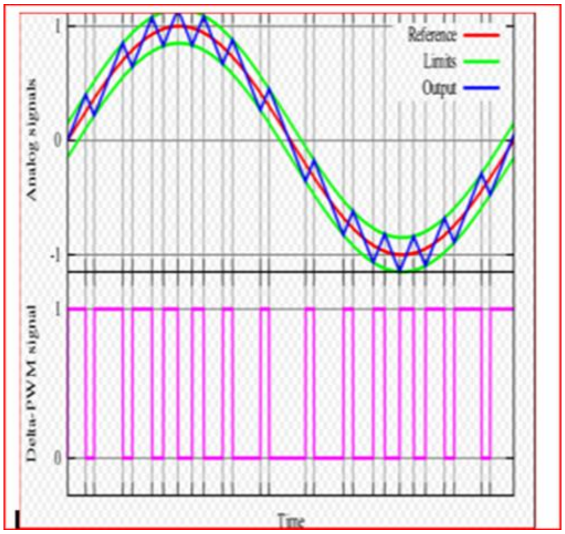


- Delta Sigma:

In delta-sigma modulation as a PWM control method, the output signal is subtracted from a reference signal to form an error signal. This error is integrated, and when the integral of the error exceeds the limits, the output changes state.

- Space vector modulation:

Space vector modulation is a PWM control algorithm for multi-phase AC generation, in which the reference signal is sampled regularly; after each sample, non-zero active switching vectors adjacent to the reference vector and one or more of the zero switching vectors are selected for the appropriate fraction of the sampling period in order to synthesize the reference signal as the average of the used vectors.



There are three types of pulse-width modulation (PWM):

1. The pulse centre can be fixed at the time window's centre, and the pulse's two edges can be changed to compress or expand the width.
2. The lead edge of the window can be kept at the lead edge and the tail edge modified.
3. The lead edge can be modulated while the tail edge is fixed.

IV. SPEED CONTROL OF D.C. MOTORS

The speed of a D.C. motor can be calculated using the formula below.

The speed is determined by the supply voltage V, the armature circuit resistance Ra, and the field flux, which is produced by the field current, as shown in the equation above. In practise, speed control is achieved by varying these three elements. As a result, there are three general methods for controlling the speed of D.C. motors.

- Armature resistance control, also known as Rheostat control, is a way of varying the resistance in the armature circuit.
- Field flux fluctuation Field flux control is the name of this technique.
- Changes in the applied voltage Armature voltage control is another name for this method.

V. DC SPEED MOTOR CONTROL USING PWM METHOD

This method is also known as armature voltage control. To reduce excessive heat dissipation in linear power amplifiers, pulse width modulation is used in DC motor control. Large heat sinks and, in some cases, forced cooling are used to solve the heat dissipation problem. Because of their substantially higher power conversion efficiency, PWM amplifiers considerably decrease this difficulty. Furthermore, the PWM driver's input signal can be obtained straight from any digital system, eliminating the need for any D/A converters. There are some drawbacks to using a PWM power amplifier. The required signal is converted to the time duration (or duty cycle) of a pulse rather than a voltage amplitude. This is clearly not a linear process. However, the PWM can be approximated as linear using a few assumptions that are usually applicable in motor control (i.e., a pure gain). The average voltage is equal to the integral of the voltage waveform in the linear model of the PWM amplifier.

Consequently, $V_{eq} * T = VS * T_{on}$

The supply voltage (+12 volts) is denoted by VS.

Ton = Time between pulses

Veq is the motor's average or equivalent voltage.

T = Time between switches (1/f)

300Hz is the recommended switching frequency.

The motor and amplifier characteristics influence the switching frequency (1/T).

The duty cycle, which is Ton / T, is the control variable. At each sampling interval, the duty cycle must be updated. As a result, the voltage seen by the motor is Veq, which is equal to the duty cycle multiplied by the supply voltage.

CONCLUSION

The dc motor speed is regulated by a power electronic device, which uses PWM to control the dc motor speed. The needed input speed will determine the speed of the speed pulse train. This circuit can be used to run dc motors at the desired speed with little losses and at a low cost. The circuit has a quick response time. As a result, excellent reliability is possible. The circuit was successfully tested for a variety of speed inputs. The approach already uses a traction system and has a bright future ahead of it.

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