Research Article

Power Analysis and Speed Control of DC Motor Drive using Matlab Simulation

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Abstract

For ensuring the flexibility and safety of a test stand system the analysis of mechanical and electrical properties of electrical machines are necessary. If in real practice these have to be obtained, it is necessary that the operating regime has to be changed so it is necessary and better to build a control system that regulates the electrical machine [for example starting of the m/c, stopping of the m/c, accelerating, retarding reversing, , braking, etc.). This paper presents an analysis of power, voltage, speed and current of DC motor drive using Matlab simulation. Variable speed drives that are variable and are in rotating motion of the electrical devices such as DC motor drive that are used to regulate the speed. Besides this it accelerates and gives a direction of movement. Electrical variable speed drives consist of three components: A controller of high level that can accommodate the use of various switches/buttons and potentiometers for starting, stopping, and changing the speed; the controller of the drive that is enable to converts the fixed voltage and frequency of power source of AC type in power output of adjustable type for controlling the electric drive motor in the specific permitted speed ranges, also control the drive motor that is capable of converting electrical energy into the movement of the motor. Variable speed drives that may finely and smoothly regulate the speed to any desired value within the design constraint and to a predefined working range can be taken as a particular approach to regulate electrical equipment and improving the various processes in which the electrical machines are involved. It was found from results of simulation that the output voltage of the rectifier, speed, torque and current ripples can be represented specially in single-phase models. In 3-phase model which has 3 inputs voltage and base voltage, an instrument to measure the power factor is added, which is equal to tan-1(Q/P), it can be noticed that the mean value of power factor at low speeds (0-2) seconds is 0.053, while at high speeds it reaches to 0.93 which means that the motor should worked at its related speed needed for the application. i.e. we should use the motors related to the needed RPM because the power is improved and at the end the efficiency is more. Steady-state regions are a good area used to measure input powers, while at transient or unsteady areas the values of power, current, torque and voltages has a big actuating error.

Keywords: Control, Electrical machines, DC motors, MATLAB, Simulation.

Introduction

The examination of electrical and mechanical properties of electrical machines is crucial for making certain the flexibleness and safety of a check stand system. so as to get these options in fact, it's necessary to interpret changes within the operational regime, therefore it's acceptable to construct a bearing system that regulates the electrical machine (starting, stopping, retarding, fast, braking, reversing, etc.). Variable speed drives, which can swimmingly vary the speed to any worth at intervals their style operating vary, square measure a typical approach to control electrical instrumentality, rising the processes within which the electrical machines square measure concerned.

Looking on the machine's specifications, electrical energy (DC) drives and variable frequency Variable Frequency AC Drives (VFD) square measure utilized. The main operate of variable speed drives in rotating electrical machines is to regulate speed, acceleration, and direction of movement [1-3].

Electrical variable speed drives [2] involve 3 elements: the high-level controller, that permits the utilization of buttons, switches, and potentiometers to start out, stop, and alter speed; the drive controller, that converts the fastened voltage associate degreed frequency of an AC power supply into adjustable power output to regulate the electrical drive motor over the allowed vary of speeds; and therefore the drive motor, that converts voltage into motor movement [1-3]. The aim of this study is to supply a MATLAB application for dominant and characterizing the first variables of spinning electrical machinery.

Literature Review

Srivastava and Datta (2017) investigated and sculptured the numerous sources of power quality disruptions during a distributed power network. Developing electrical power network today is also seen of as a medium that promotes energy exchange among its customers, wherever network customers aren't completely finish users of electricity. As a result of energy is changed by voltages and currents, the restrictions on their deviations from the value ought to be closely ascertained. New developments, like the combination of spread generation into the network system and breakthroughs in converter-based hundreds, have caused several disruptions that interfere with the sleek interchange of energy among network users. Moreover, electrical power quality has become a crucial issue within the deregulated power systems. it's one in every of the differentiating factors among competitive suppliers. therefore there's a requirement to deal with the causes that square measure behind these disturbances. In their system MATLAB primarily based modeling and simulation of assorted Power quality disturbances is allotted. Four unremarkably encountered disturbances particularly Sag, Swell, harmonic, Transient square measure studied and sculptured [4].

Campos et al. (2022) projected a MATLAB program for characterizing and analyzing electrical machine behavior. The analysis is being conducted at the University of Almeria's (Spain) laboratory and is particularly developed to observe the functioning and power quality of electrical devices. it's created of multiple take a look at benches that give numerous configurations of the laboratory's electrical devices. an automatic and changeable frequency AC drive controls the electrical machinery. so as to change numerous input parameters, the MATLAB program connects in real time with the adjustable frequency AC drive through typical industrial communication protocols and open supply libraries (start, stop, motor speed, etc.). what is more, the appliance displays some vital output parameters, like the RMS voltage, RMS current, active power, speed and torsion. additionally, this framework is additionally designed to observe power quality and to investigate the operation of the electrical machines, together with the possibility of applying advanced techniques for prediction and correction of rotating electrical machines maintenance [1].

Kumar and Kaur (2015) introduced for the generation of power quality events and classification of those events mistreatment radial basis perform neural network. the ability quality events square measure generated by developing an electrical power distribution model mistreatment Sim-Power system in MATLAB/Simulink. This creates power quality events like sag, swell, interruption, harmonics, transient, noises etc. and these signals square measure valid by the virtual signals generated by constant quantity equations [5].

Hussein and Hawas (2019) created a full system associated with all conditions of power quality event mistreatment MATLAB/SIMULINK and constant quantity equations. Power quality interruptions have developed as a significant issue for utility and customers within the current allocation system. This technique integrates two condenser banks, a line fault, the start of associate degree induction motor, a non-linear load, and electrical device energizing to simulate numerous forms of voltage sag. within the general model, voltage provisionary through distribution network created as a consequence of influence condenser bank change version is simulated. To be clear, this model has been increased with associate degree integrated block and setting within which all event conditions square measure structured for energy quality while not distorting the substance of it. This model Integrated is simply too useful to simulate completely different energy quality waveforms. The performance of the different machine-controlled categorization algorithms received square measure applicable for checking waveforms of power quality [6].

Kumar and S. kumar (2021) created a Simulink model of a three section supply is fetched ANd converted to variable AC through the device circuit associate degreed fed as an input to the commonly used industrial motor drive is supposed at the aspect of overcurrent current protection system. It jointly visualizes the fault incidence parameters with the help of displays on the thought-about industrial drive and the way to forestall the injury of drive caused attributable to incidence of fault [7].

Modeling and MATLAB simulation

As in any motor, the DC brush motor consists of the stator coil (fixed) half and also the rotor (movable) half. The DC brush motor conjointly has 2 styles of windings-the excitation or coil and also the coil winding [8-10]. Note that the voltage supply amplitude and frequency values required for every drive model of the electrical Drives models are often found within the reference notes. The nominal values of the corresponding motors also are enclosed. The table contains the values love the DC3 two hundred power unit model. the planning values square measure shown in table onebelow.

Table 1. Parameters of Design used in simulation

Motor nominal values	**Voltage**	**500 Volt**
	Speed	1750 rev/min
	Power	200 horse power
Drive input voltage	Frequency	60 hz
	Amplitude	460

Matlab simulation models

Figure 1 shows the Single phase Matlab simulation Model of the DC motor drive. It consists from many components like input power source, the DC motor drive, rectifiers etc.
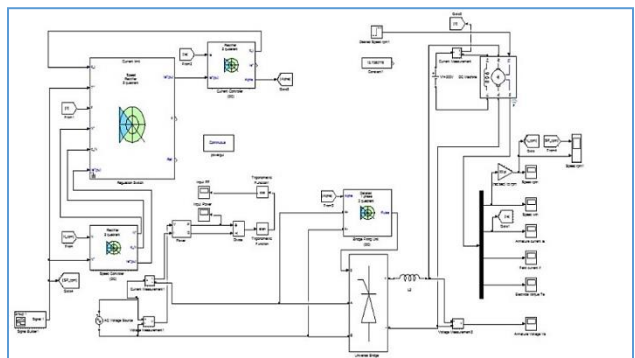

Figure 1. Block diagram of single-phase motor drive simulation

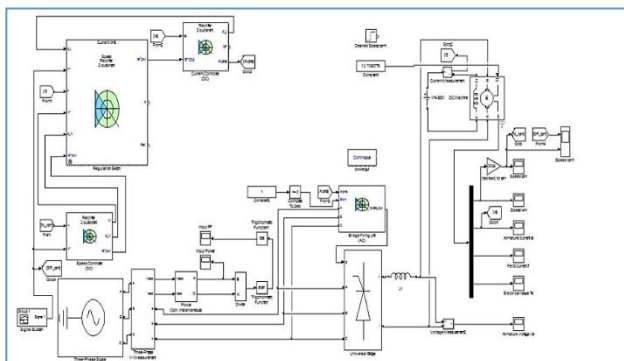Figure 2 shows the three-phase simulation model of the DC drive motor.

Figure 2. Block diagram three -phase motor drive simulation

Results and Discussion

Single Phase Results

Figure 3 shows the speed in rpm Single phase case regulation as function of time
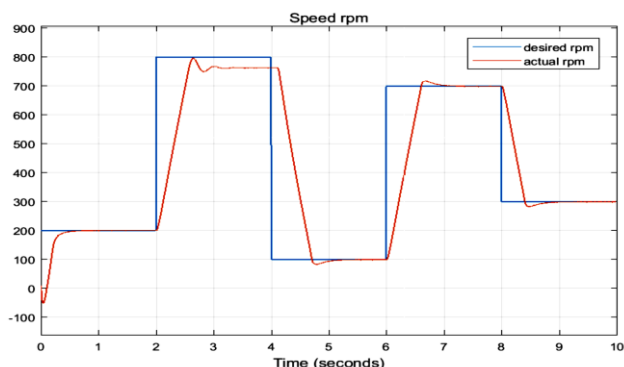
Figure 3 Diagram of speed control as a function with time of single-phase case.

Figure 4 shows the armature current variation with time for single phase DC motor drive.
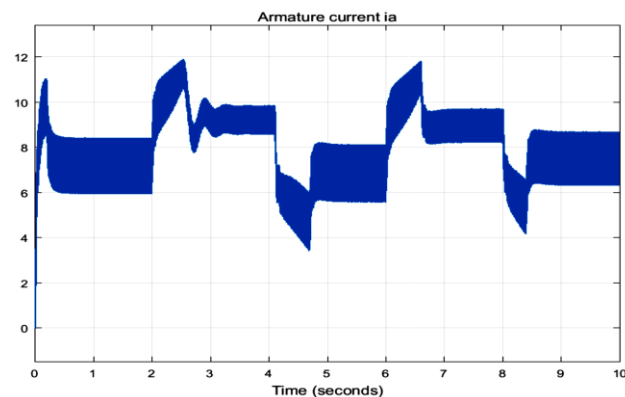

Figure 4. Armature current variation with time for single phase DC motor drive

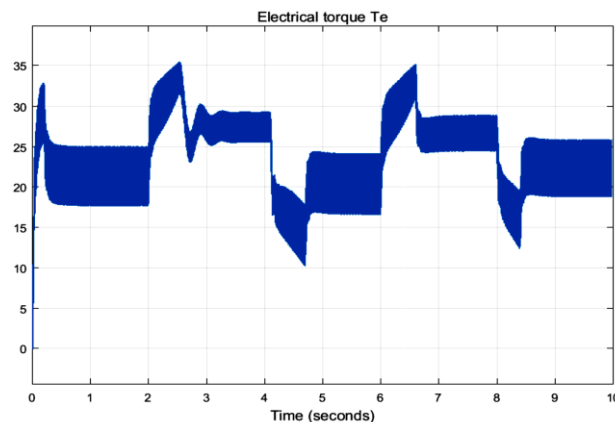Figure 5 shows the torque of the DC motor drive as a relation with time.

Figure 5. Torque of the DC motor drive as a relation with time

Figure 6 shows the armature voltage control diagram of the DC motor drive as a function with time.
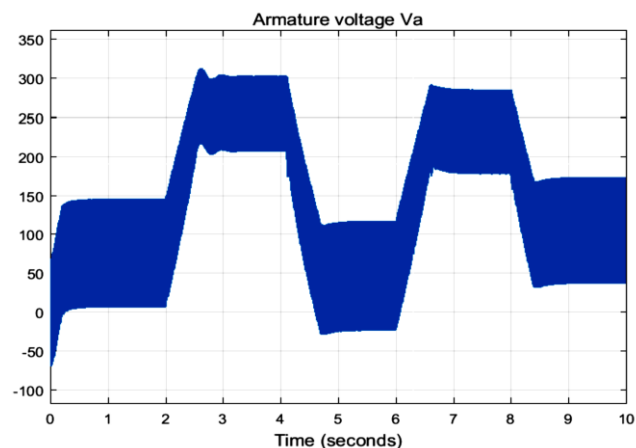

Figure 6. Armature voltage control diagram of the DC motor drive as a function with time

Three Phase Results

In this section the results of simulation (after run) is demonstrated, power factors, armature current, voltages and torque of the DC drive motors in two cases: single and 3-phseses are discussed. Also the main parameter studied in this paper: the speed controlling is discussed here for the two cases: single and 3-phase DC motors. Figure 7 shows the Power factor signal resulted from three phase system as a function with time.
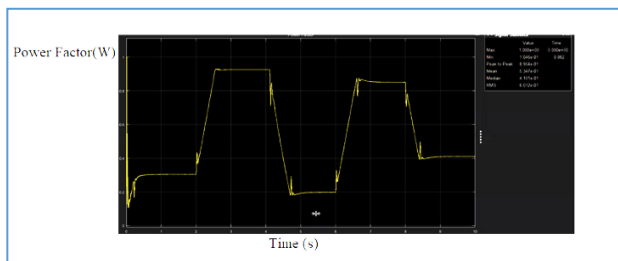

Figure 7. Power factor signal resulted from three phase system as a function with time

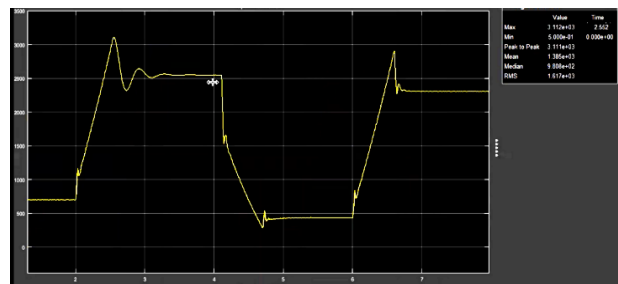Figure 8 shows the Input power response -3 phase

Figure 8 Input power (W) response: 3 phase VS. Time (s)

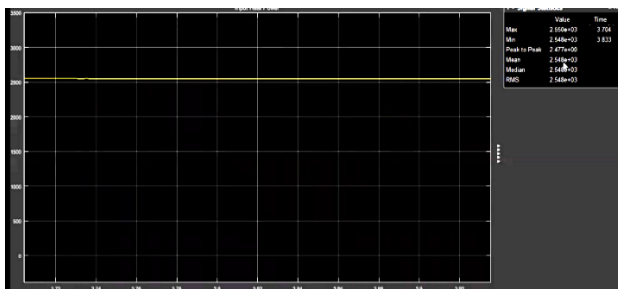Figure 9 shows the Input power response at one of stable areas

Figure 9 Input power response (w) at one of stable areas Vs. Time (s)

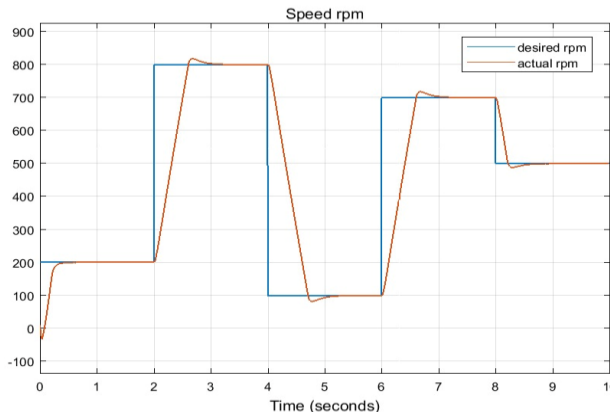Figure 10 shows the speed in rpm 3- phase case regulation as function of time

Figure 10. Speed control diagram as a function with time of 3- phase case

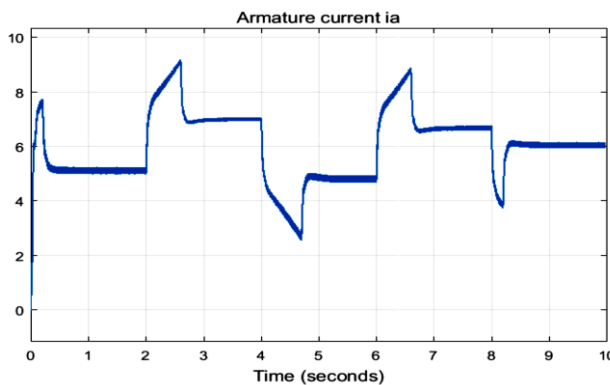Figure 11 shows the armature current variation with time for 3-phase DC motor drive.

Figure 10. Armature current variation with time for 3-phase DC motor drive

Figure 11 shows the torque of the DC motor drive as a relation with time for 3-phase DC motor drive
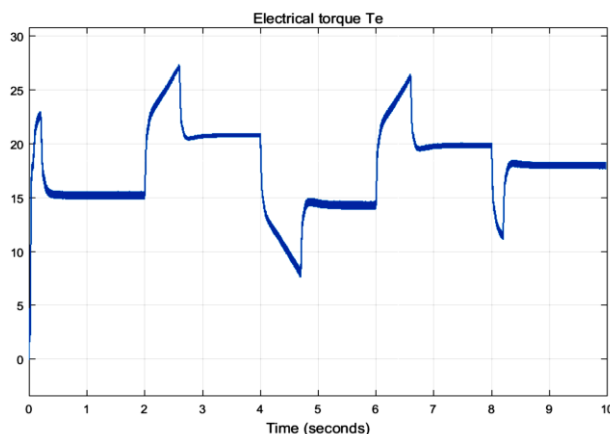

Figure 11. Torque of the DC motor drive as a relation with time in the case of 3-phase DC motor drive

Figure 12 shows the armature voltage control diagram of the DC motor drive as a function with time.
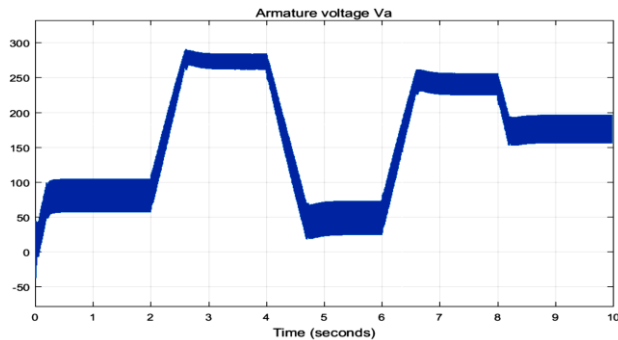
Figure 12 shows the armature voltage control diagram of the DC motor drive as a function with time-3-phase DC motor drive

Discussion

The figures show both single and 3-phases motor drive control system with rectifier, the objective was to design a controller to make a speed control for DC motor drive or speed regulator by changing the rectifying angle to get a set of points of the speed as possible. The input power can be calculated as active and reactive values. In single phase, and from the power factor values of the system after running for a slot of time, it can be noticed that the system at low speeds can be tracked in good way, but at high speeds the tracking of the system is difficult to be tracked for some limit because for single phase the values of speed control is limited by the rectifying angle (α), which consider as a disadvantage for single phase motors model. It can be noticed that for single phase case the frequency is doubled to reach a value of 120 Hz with some ripple or distortion for values of armature current, torque and voltage signals as shown in figure 4 to 6, while in 3-phase models the ripple is low because of high values of gain steps which reaches to 6 steps which means more controlling of speed, current and voltage and also torque. So, it can be concluded that 3 phase systems is preferred at high speeds of drive motor applications than that of single phase models which works efficiently at low speeds of the motor. From simulation results: the rectifier output voltage, torque, speed and current ripples are represented specially in single-phase models.

In 3-phase model which has 3 inputs voltage and base voltage, an instrument to measure the power factor is added, which is equal to tan-1(Q/P), it can be noticed that the mean value of power factor at low speeds (0-2) seconds is 0.053, while at high speeds it reaches to 0.93 which means that the motor should worked at its related speed needed for the application. i.e. we should use the motors related to the needed RPM because the power is improved and at the end the efficiency is more. Steady-state regions are a prominent area used to measure input powers, while at transient or unsteady areas the values of power, current, torque and voltages has a big actuating error.

Conclusions

In this paper the DC motor drive system is simulated in two cases while using single-phase and 3-phase voltages, the results shows that using single phase voltages DC motors has a good efficiency of power factor, current, torque and speed controls at low speeds (rpm) with some ripple in such values, while in three-phase DC drive motors, the ripple in control signals is very low (nearly zero) at both high values of speeds and at low speeds values. It was found that we should use the motors related to the needed RPM because the power is improved and at the end the efficiency is more. Steady-state regions are a good are as used to measure input powers, while at transient or unsteady areas the values of power, current, torque and voltages has a big actuating error.

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