Speed Control of Three Phase Induction Motor by V/f Method for Batching Motion System

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ABSTRACT

The electric drive systems used in industrial applications are increasingly required to meet the higher performance and reliability requirement. Today about 90% of all industrial motor applications use three phase induction motors because they are simple in design, easy to maintain, and are less costly than other designs.

The paper is depend upon the batching system which is one application of weaving machine which rolls the cloth with specific tension so that it should neither slacken the cloth nor tightened it by replacing DC system with the AC system.. The motion of this loom is controlled by induction motor where in the AC drive is used to run the induction motor which rotates the drum through pulleys.

Keywords - Ac drive, Batching system, Counter meter, Encoder, Gear box, Encoder, Three phase induction motor

I. INTRODUCTION

Induction motors are widely used in many residential, commercial, industrial and utility applications. This is because the motor have low manufacturing cost, wide speed range, high efficiency and robustness [1].But they require much more complex methods of control, more expensive and higher rated power converters than DC and permanent magnet machines [2]. Previously, the variable speed drives had various limitations such as poor efficiencies, larger space, low speed and etc. the power electronics transformed the variable speed drive into a smaller size, high efficiency and high reliability [3]. The development of speed control system using frequency control has been designed by combinations of PWM control circuit, driver circuit and H-bridge inverter which makes the system simple, robust and compact open loop PWM controller circuit to control single phase induction motor and single phase induction motor can be driven to variable speed and frequency[4]. But it is desirable to replace the single phase induction motor drives by three phase induction motor drives in residential appliances, farming and low power industrial applications [5].Induction motors have performed the main part of many speed control systems and found usage in several industrial applications. The advances in microprocessor and power electronics gives permission to implement modern techniques for induction machines such as field oriented control [6].slip frequency control [7]. Then a modern speed Ac machine system is equipped with adjustable frequency drive for speed control of electric machine. The speed of machine of machine is controlled by converting fixed voltage and frequency to adjustable values on machine side. The three phase inverter circuit changes the DC input voltage to three phase variable frequency variable voltage output. The three phase Ac is rectified into DC and then filtered to minimize the ripple current. This controlled dc is converted into controlled pulses by means of voltage to frequency converter. These controlled pulses are fed to Inverter Bridge for producing variable voltage variable frequency output. This output is fed to induction motor for controlling it's speed [8]

This paper gives idea about to implement variable speed drive for maintaining the constant speed of three phase induction motor as batching system requires constant speed. The synchronization is necessary between batching system and weaving machine and this can be done by using variable voltage variable frequency method with the help of AC drive. This paper explains the batching motion system as weaving application.

II DC SYSTEM

The batching motion is a system specially designed for continuous motion of roll of different mills such as textile mill, paper industry, polythene industry, etc. Batching rolls the cloth with synchronized speed and specific tension such that it should neither slacken the cloth not tightened it. The motor used is permanent magnet DC motor. The motor used is of very small rating but this motor is used to rotate gear and total weight of fabric is taken by gear.

2.1 Drawbacks: It require higher cost, its capacity is lower that is it rolls the cloth up to 1000 meter. It has very complicated circuitry such that it requires transformer, rectifier, relay, switches, fuse and potentiometer and there is no protection and no indication for thermal alarm and over current. It requires specially designed combination of motor and gear box which is very expensive. As motor and gear box is not separate, if any problem arises in motor or in gear box, the whole system has to be changed and for this the batching system has to depend upon OEM (Original Equipment Manufacturer) and it requires one to two months time period from the date of delivery, so there will be a very much loss of production in the industry and this dc system is very costly. This system wind up the cloth up to 1000 meter. Dimmer stat is used for speed control. By connecting rheostat in the armature circuit of motor or by flux control method the speed of dc motor can be controlled and dimmer stat is used for speed control of dc motor. By keeping these things in mind it will be beneficial to replace the dc system by robust system which is user friendly by using simple drive and AC motor which is easily available in Indian market with low cost, low maintenance and simplified circuitry. Motor torque, motor speed, motor current, input supply has to consider by designising of new system. The original system used is permanent magnet dc motor and the ratings of motor are

180 V,1500 rpm, 50 W, 0.3 N-m, R= 31.5 Ohm, L = 70 mH

By using reduction gear ratio it's speed is dropped to 6.9 rpm.

III AC SYSTEM

The above all drawbacks can be removed by replacing the DC system by AC system in which three phase squirrel cage induction motor is used. The ratings of three phase induction motor selected as it requires one frame size greater motor than Dc motor.

The ratings of three phase induction motor are
0.25 KW, 1350 rpm, 0.19 Amp

The torque of motor is calculated as

$$T = \frac{9.55*0.25*1000}{1380}$$

T = 1.73 Nm

It is required to fulfill the requirement of batching system.

The speed of motor is reduced to 6.9 rpm by gear box, chain pulley and sprocket mechanism. The motor of any make can be selected. Gear ratio is selected according to service factor. Service factor can be determined according to the type of duty, number of starts per hour and duration of service. The gear ratio can be selected according to service factor and application for which it is used and is calculated as required output speed n_2 and available input speed n_1.

IV AC DRIVE

AC drives, inverters and adjustable frequency drives all terms that are used to control the speed of AC motor. AC drives receive AC power and convert it to an adjustable frequency, adjustable voltage output for controlling motor operation. The three common inverter types are current source inverter (CSI), voltage source inverter(VSI) and pulse width modulation inverter(PWM).

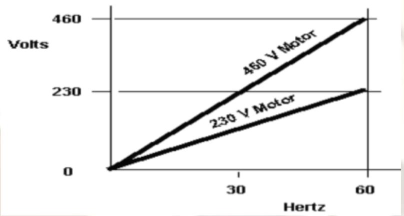
4.1 Variable voltage inverter

This inverter uses an SCR converter bridge to convert incoming AC voltage into Dc voltage. It controls the value of rectified DC voltage from 0 to 600 V DC. The choke and capacitor make up Dc link section and smoothened the converted DC voltage.

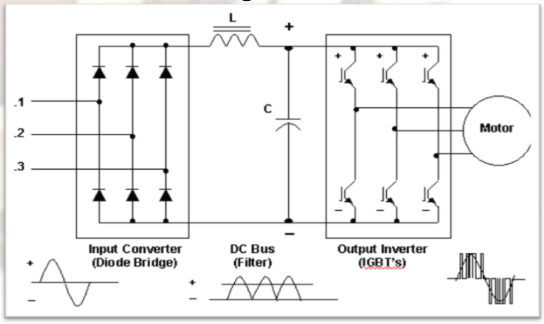
4.2 Pulse width modulation drives

A basic PWM drive consist of a converter, DC link, control logic and inverter. Siemens MICROMASTER and MASTERDRIVE are like PWM drives which provide more sinusoidal current output to control voltage and frequency applied to the motor. A PWM drive is more efficient and typically provides higher level of performance. It can adjust the speed of motor by changing the frequency applied to the motor. Motor speed can adjust by adjusting the number of poles of motor, but this is physical change to the motor. It requires rewinding and result in step change in speed. Figure shows torque developing characteristics of motor: the volts per Hertz ratio. This ratio is changed to change the motor torque. A drive provides many different frequency outputs.

Torque Developing Characteristics of Motor



PWM drive Block Diagram:



Although some drives accept single-phase input power, are going to focus on the 3-phase drive. The input section of the drive is the converter. It contains six diodes, arranged in an electrical bridge. These diodes convert AC power to DC power. The next section-the DC bus section sees a fixed DC voltage. The DC Bus section filters and smoothes out the waveform.

Ac drives, inverters and adjustable frequency drives are all terms that are used to refer to equipment designed to control the speed of AC motor.

4.3Torque boost parameter:

Acceleration and deceleration time:

The acceleration time defines the time duration in which Ac drive reaches its maximum frequency after a start signal is issued.

Short acceleration times are usually for light loads and long acceleration times for heavy loads.

The deceleration times defines the time duration in which the AC drive reduces the output frequency from the maximum frequency to 0 Hz after a stop signal. The deceleration time function allows the load to be stopped more quickly.

When a motor is started or stopped using linear acceleration and deceleration patterns, its rate of change until it reaches full speed or comes to a complete stop is linear.

When the motor is started or stopped using s shape acceleration or deceleration pattern, its rate of change gradually increases or decreases until it reaches full speed or comes to a complete stop.

If the mass inertia moment of connected load is high, it may be necessary to increase the output voltage beyond the normal V/f Characteristics at low output frequencies. This compensates for the voltage drop in the motor winding and can be up to half of motors nominal voltage. The torque boost is defined as a percentage value. The ACS 550 drive has to be selected.

4.4 IR Compensation:

When IR compensation enabled, it provides an extra voltage boost to the motor at low speed and It sets the IR compensation voltage used for 0 Hz. IR compensation factor is required when it is required to start the motor at loaded condition when any fault arises on motor and for that higher torque is required and this can be done by IR compensation which boost up the voltage and torque increases and it is necessary to keep the IR compensation as low as possible to prevent overheating.

KW	3	7.5	15	37	132
IR Compensation Voltage	18	15	12	8	3

The motor, drive and supply power must be compatible:

Motor specification	*Verify*	*References*
Motor type	*3 phase induction motor*	-
Nominal current	*Motor value is within this range 0.2…2.0*	*Type designation label on drive, entry for output current*
Nominal frequency	*10…500 Hz*	-
Voltage range	*500…600 V drive*	

Motor Start up Data:

code	Name	Range
9901	Language	
9904	Motor control mode	1=vector:speed 2=vectot:torque 3=scalar:frequency
9905	Motor nominal voltage	115…345 200…600 230…690 288…862
9906	Motor nominal current	0.2…. 2.0….
9907	Motor nominal frequency	10 to 500 hz
9908	Motor nominal speed	50 to 30000 rpm
9909	Motor nominal power	0.2 to 3.0

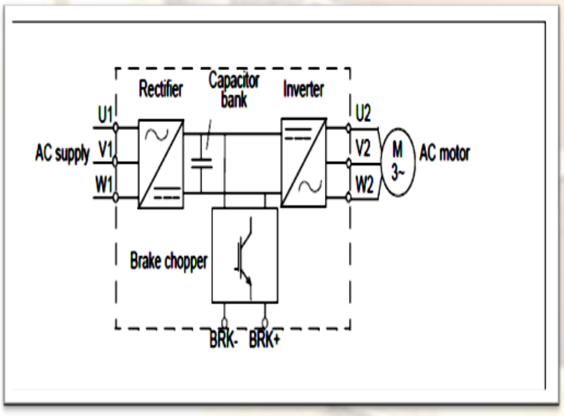
Operation Data for drive:

Code	Name	Range	Resolution	Default
0101	Speed & Direction	-30000…30000	1 rpm	-
0102	Speed	0…30000	1 rpm	-
0103	O/p Freq	0…500	0.1 Hz	-
0104	Current	0…2.0	0.1 rpm	-
0105	Torque	-200…200 %	0.1 %	-
0106	Power	-2…2.0	0.1 KW	-
0110	Drive Temp	0…150°c	0.1%	-

V Operation principle

The ACS150 is a wall or cabinet mountable drive for controlling AC induction motors. The fig below shows the simplified main circuit diagram of the drive. The rectifier converts three-phase AC voltage to DC voltage. The capacitor bank of the intermediate circuit stabilizes the DC voltage. The inverter converts the DC voltage back to AC voltage for the AC motor. The brake chopper connects the external brake resistor to the intermediate DC circuit when the voltage in the circuit exceeds its maximum limit.

Circuit Diagram of Drive:

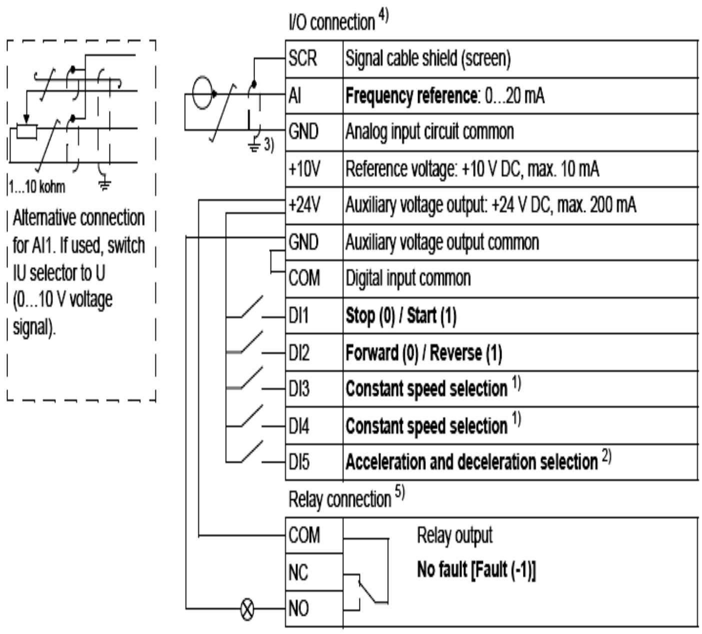


The default connection of the control signals depends on the application macro in use. There are different types of connection made in these terminals as per application and that are already specified by company. These different type of connection are called as Macro.

This is the default macro. It provides a general purpose I/O configuration with three constant speeds.

Standard Macro Connections:

Default I/O connections



5.1Standard Macros of the Drive:

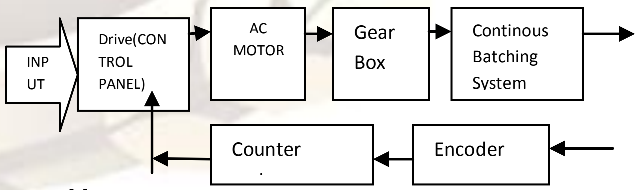
Macros are nothing but the general configuration provided on the drive panel for input output connections like reference voltage, start command, stop command, etc. No and NC contacts are given on the panel are specially for synchronisitio purpose.

Applic Macros: This Macro selects as application macros. Application macros automatically edit parameters to configure the drive for various applications.

The applic macros are

1= ABB standard	2= 3 wire
3= Alternate	4= Motor Pot
5= Hand/Auto	6= PID control
7= PFC control	8= torque control

VI Methodology



Variable Frequency Drive For Weaving Application

The gear ratio is calculated as

$$i = \frac{\text{speed at output shaft of motor}}{\text{Required speed}}$$

$$i = \frac{1350}{7}$$

i = 200

Gear ratio is selected as 200:1

The encoder counts the speed of batching motion system in rpm (Revolution per Minute) and convert it into pulses. It counts 100 pulses for one revolution and given it to the counter meter in which the machine speed is already set. If machine speed does not match with set speed it generates the voltage 4 to 20 Volts and provides it to input of drive and accordingly drive control the motor by v/f method.

VII CONCLUSION

Through this project we have replaced the existing DC system with the AC system and the results are as follows:

1. We are able to achieve 7 rpm which was also possible with the help of DC system. As we have used induction motor we may improve it further
2. Since we are using V/f control method we can vary voltage and frequency as per requirement of torque and speed.
3. Efficiency can be adjusted with the designed of Induction motor at required torque.

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