Labview Based Speed Control of Single Phase Induction Motor by V/F Control Method

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Abstract— Induction Motors are also known as "Workhorse of the Industry". This is because it is one of the most widely used motors in the world. It is used in transportation, industries, household appliances, and laboratories. The speed control methods are pole changing, frequency variation, variable rotor resistance, variable stator voltage, constant v/f control, slip recovery method etc., Except V/f control method, all methods have certain limitation. In the proposed method, the V/f ratio is kept constant using LabVIEW which in turn maintains the magnetizing flux constant so that the maximum torque remains unchanged and the efficiency gets maintained. Thus, the wide range of speed control is achieved. It is effortless, cost-effective and easier to design in open loop. This proposed method can be extended in future to control the speed of induction motor in closed loop. In closed loop method, the steady state and outputs are controlled much higher than open loop.

Key words: LabVIEW, V/f Ratio, Open loop, Induction Motor

I. INTRODUCTION

For domestic, commercial and in industrial purpose single phase power system is highly used compared to three phase system. Single phase motors are used in vacuum cleaner, washing machine, centrifugal pumps, and blowers because of simple construction, reliable and easy to repair.

The major reasons behind the popularity of the Induction Motors are:

1) Squirrel-Cage Induction Motors are used in all environmental condition for a long time because of robustness of motor.
2) Induction motor is highly reliable and has high efficiency.
3) Induction motors are simple in construction and also low maintenance costs.
4) Speed control is possible in Induction Motors. So Induction motor is used in different applications. It also has high torque hence used in application where the load is applied before starting the motor.

A. *Necessity of Speed Control of Induction Motor*

- It ensures smooth operation
- It provides torque control and acceleration control
- Different processes require the motor to run at different speeds
- It compensates for fluctuating process parameters

All these factors presents strong case for the implementation of speed control or variable speed drives in Induction motors. Speed control of Induction motor is achieved by either rotor resistance control or stator voltage control. But both the methods result has very low efficiencies at lower speeds. Varying supply frequency is the efficient method for Induction motor speed control.

B. *Methods of Speed Control of Induction Motor*

1) *From stator side:*

- Supply frequency control / (V/F) control
- Supply voltage control
- Controlling the number of stator poles
- Stator resistance control method

2) *From rotor side:*

- Rotor resistance control method
- Cascade control method
- Injecting slip frequency emf /voltage into rotor circuit

C. *V/F Control*

The torque developed in the induction motor is directly proportional to the ratio between applied voltage and the supply frequency. By varying the voltage and the frequency, maintaining their ratio constant, the torque developed can be kept constant throughout the speed range.

II. VARIABLE FREQUENCY CONTROL

The motor speed can be controlled by varying supply frequency. Voltage induced in stator is proportional to the product of supply frequency and air-gap flux. If stator drop is neglected, terminal voltage can be considered proportional to the product of frequency and flux. Without a change in the terminal voltage, any reduction in the supply frequency causes an increase in the air-gap flux. In order to make use of the magnetic material, induction motors are designed to operate at the knee point of the magnetization characteristic. Due to this, increase in flux will saturate the motor. This will increase the magnetizing current, distort the line current and voltage, increase the core loss and stator copper loss, and produce a high-pitch acoustic noise. Therefore, the variable frequency control is generally carried out at rated air-gap flux by varying terminal voltage with frequency in order to maintain (V/f) ratio constant at the rated value.

$$\mathrm{Tmax} = \frac{K\left(\frac{V}{f}\right)^2}{\frac{Rs}{f} \pm \left[\left(\frac{Rs}{f}\right)^2 + 4\pi^2 (Ls+Lr')\right]} \quad \text{---------} \ (1)$$

Where K is a constant, and Ls and Lr' are, respectively, the stator and stator referred rotor inductances. Positive sign is for motoring operation and negative sign is for negative operation.

When frequency is not low, (Rs/f)<<2π(Ls+Lr') and therefore,

$$\mathrm{Tmax} = \pm \frac{K\left(\frac{V}{f}\right)^2}{2\pi(Ls+Lr')} \quad \text{---------} \ (2)$$

The above equation suggests that with a constant (V/f) ratio, motor develops a constant maximum torque,

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except at low speeds (or frequencies). Motor therefore operates in constant torque mode.

In this proposed method, the speed of single-phase induction motor is being controlled by varying supply voltage and frequency with constant (V/F) ratio. It is simple, economic and easier to design and implement in open loop. But drawbacks in open loop is, it doesn't correct the change in output also it doesn't reach the steady state quickly. These drawbacks can be overcome by modifying an open loop into a closed loop system. In this work, open loop speed control of induction motor have been implemented in hardware. This can be extended in future to control the speed of induction motor in closed loop. According to equ (1), for low frequencies (or low speeds) due to stator resistance drop [i.e., when (Rs/f) is not negligible compared to 2π[(Ls + Lr')] the maximum torque will have lower value in motoring operation (+ve sign) and larger value in braking operation (-ve sign). This behavior is due to reduction in flux during motoring operation and increase in flux during braking operation. When it is required that the same maximum torque is retained at low speeds also in motoring operation, (V/f) ratio is increased at low frequencies. This causes further increase in maximum braking torque and considerable saturation of the machine in braking operation.

When either V saturate or reaches rated value at base speed, it cannot be increased with frequency. Therefore, above base speed, frequency is changed with V maintained constant. According to equ (2), with V maintained constant, maximum torque decreases with increase in frequency (or speed).

Variation in terminal voltage with frequency is therefore as shown in fig.1. V is kept constant above the base speed. Below the base speed (V/f) ratio is increased to keep maximum torque constant. Corresponding speed torque curves are shown in fig.2 both for monitoring and breaking operations. The curve shows that the speed control and braking operation are available from nearly zero speed to above synchronous speed.

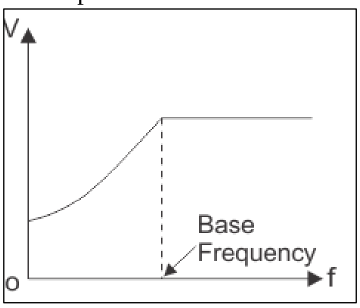

Fig. 1: V-f Relation

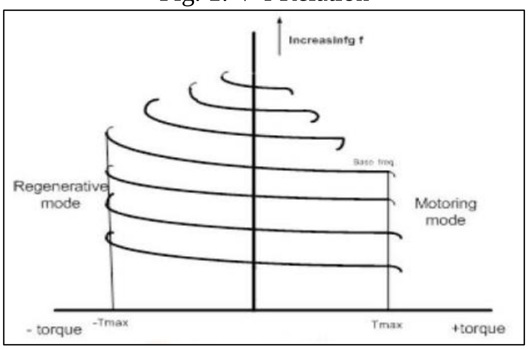

Fig. 2: Speed-Torque characteristics

A given torque is obtained with a lower current when the operation at any frequency is restricted between the synchronous speed and the maximum torque point, both for motoring and braking operations. Therefore, the motor operation in each frequency is restricted between the synchronous speed and maximum torque point as shown by solid lines in Fig.2.

The squirrel cage induction motor has a number of advantages over a dc motor. It is cheap, rugged, reliable and long lasting. Because of the absence of commutator and brushes, it practically requires no maintenance, it can be operated in an explosive and contaminated environment, and can be designed for higher speeds, voltage and power ratings. It also has lower inertia, volume and weight. Though the cost of a squirrel cage motor is much lower compared to that of a dc motor of the same rating, the overall cost of variable frequency induction motor drives, in general are higher. But because of these advantages listed above, variable frequency induction motor drives are preferred over dc motor drives. They have several other applications such as traction, mill run out tables, steel mills, pumps, fans, blowers, compressors, spindle drives, conveyors, machine tools, and so on.

III. PROPOSED SYSTEM

A. Objective of Proposed System

The main objective of the project is to control the speed of the induction motor with increase in efficiency by v/f method using LabVIEW. In this v/f control method, wide speed range control is possible and also the starting performance is improved.

B. Block Diagram

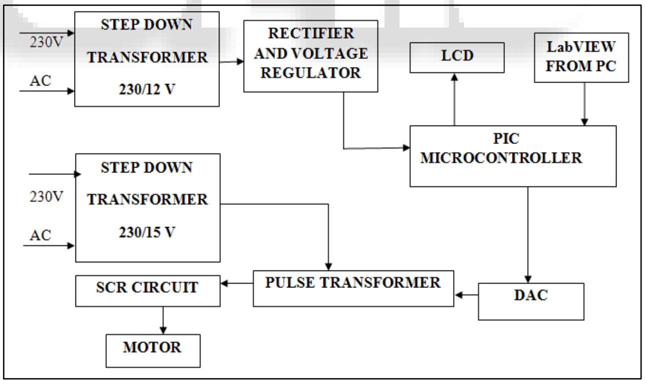

Fig. 3: Block diagram of the proposed system

A Step down Transformer is a type of transformer, which converts a high voltage at the primary side to a low voltage at the secondary side. In terms of coil windings, the primary winding of a Step down Transformer has more turns than the secondary winding. In our project by using the step down transformer we step down the 230Volt supply to 12Volt and 15Volt supply to operate the microcontroller (5V) , LCD Display(5V), digital to analog converter(±12V), thyristor control(±12V) circuit and Op-amp(±12V). A voltage regulator is used to regulate voltage level. When a steady, reliable voltage is needed, voltage regulator is preferred. For any changes in an input voltage or load conditions it generates a fixed output voltage that remains constant. It acts as a buffer for protecting components from damages. A voltage regulator is a device with a simple feed- forward design and it uses

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negative feedback control loops. There are mainly two types of voltage regulators, one is linear voltage regulators and other is switching voltage regulators. These are used in wider applications. In our project Voltage regulator is used to regulate the voltage as 5 Volt for giving the supply to the microcontroller and LCD Display and also to regulate the voltage as 12 Volt for giving the supply to digital to analog converter and thyristor triggering circuit and Op amp. Here PIC16F877 mictocontroller acts as a driver circuit to connect the PC (Labview program) with the pulse generating unit. Inorder to vary the pulse of switching circuit, we set the values in the LabVIEW programme. Then these values are seriesly transported to the microcotroller through the RS232 USB at the time of execution. LCD screen is an electronic display module and finds a wide range of applications. A 16*2 LCD display is very basic module and is very commonly used in various devices and circuits. Here LCD display is for showing the rotating speed of the single phase induction motor. The Op-amp is extensively used as main building block of digital to analog convertor. Digital to analog convertor is an electronics device in form of IC, which converts digital signal to its equivalent analog signal. The DAC can be realized in many ways. One of the popular digital to analog convertor circuit is binary weighted ladder. Here Digital to analog converter is used to convert the digital signal from microcontroller to analog signal to fed into the switching controller circuit for pulse generation. The signal amplitude and impedance matching between the source and load can be adjusted by using pulse transformer turns ratio. The pulse transformers are often used in transmitting digital data and in the gate drive circuitry of transistors, FETs, SCRs, and etc. In the further applications, the pulse transformers are referred as "gate transformers" or "gate drive transformers". Here pulse transformer is for generating the pulse to vary the triggering angle of thyristor to control the speed of the single phase induction motor.

IV. LIST OF STEPS INVOLVED IN DESIGNED PROCESS

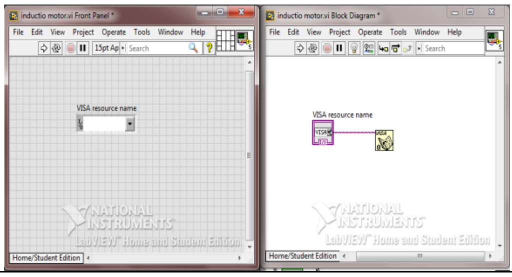
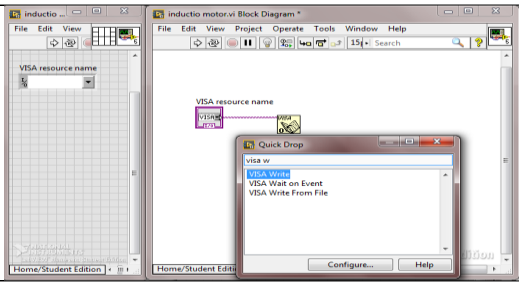
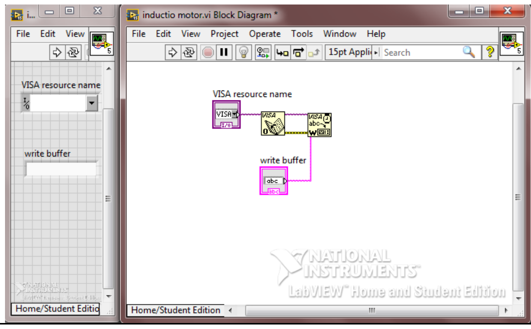
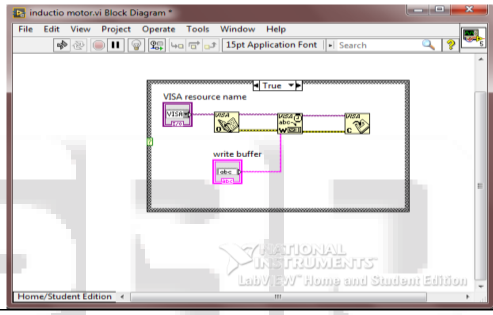
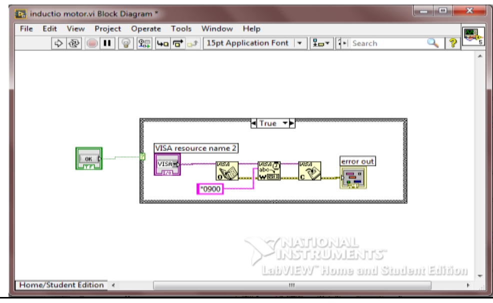
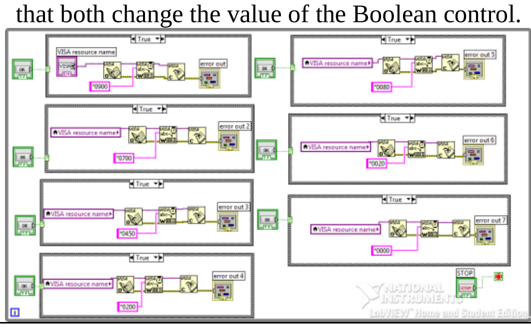
STEP 1	Open a session to the device specified by VISA RESOURCE NAME and returns a session identifier that can be used to call any other operations of that device. 
STEP 2	The data is written from the write buffer to the device or interface specified by VISA resource name. 
STEP 3	Closes a device session or event object specified by VISA resource name. 
STEP 4	Draw a case structure. The value wired to the case selector determines the case to execute. 
STEP 5	The Error in can accept error information wired from Vis previously called. Use this information to decide if any functionality should be bypassed in the event of errors from Vis. 
STEP 6	To create front panels the configurable mechanical action is used. Switch and latch actions are similar that both change the value of the Boolean control. 

Table 1: Steps involved in designed process

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V. WORKING MODEL OF PROPOSED SYSTEM

Initially 230Volt from supply is stepped down into 12V and 15V by two step down transformer respectively. Then 12V supply is given to the voltage regulator. In voltage regulator, the voltage is regulated to 5V to operate a micro controller. Then 15V supply is given to the pulse transformer via voltage regulator in order to regulate the voltage as 12V. The Microcontroller receives the signal from PC through LabVIEW programming. The motor speed is being displayed in liquid crystal display (LCD). The digital output of the Microcontroller is converted into analog signal using digital to analog converter. This DAC output is given to the pulse transformer circuit in order to vary the pulse of the thyristor. Hence the output supply voltage and frequency gets varied, correspondingly single phase induction motor speed also varied. The speed variation is shown in below mechanical setup.

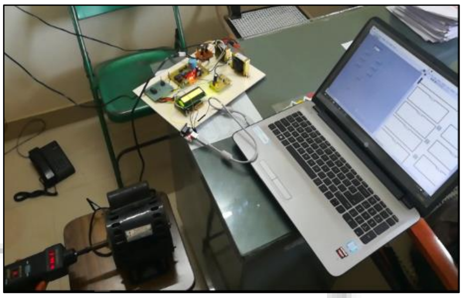

Fig. 4: Interfacing of hardware with Proposed controller

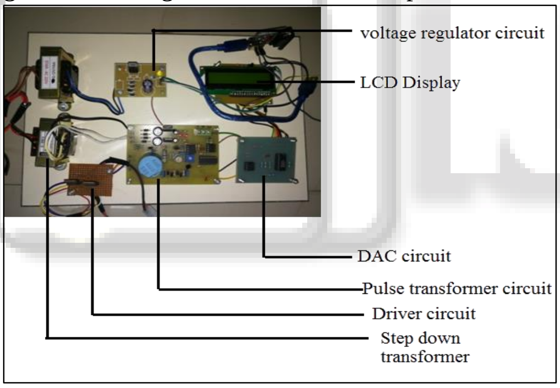

Fig. 5: Hardware Part of controller circuit diagram

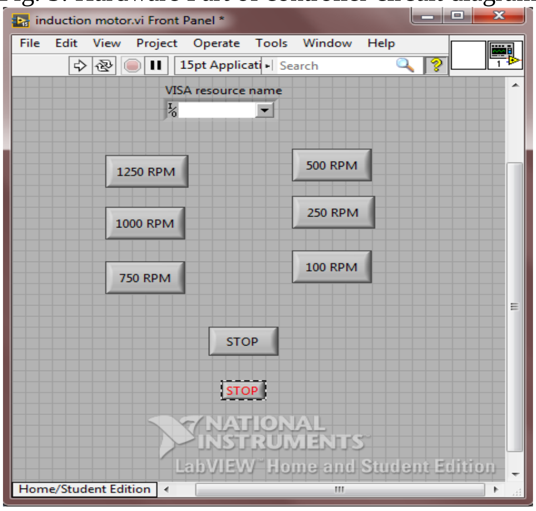

Fig. 6: Control block of Induction Motor

VI. RESULT AND CONCLUSION

Thus, by varying the supply voltage and frequency, the speed of the single phase induction motor is controlled under open loop condition. In this work, V/f ratio is maintained constant in order to control the motor speed under open loop condition. In open loop condition the steady state response has not been attain at the expected time period. The steady state and accurate output response of the proposed work could be attained at expected value in closed loop system.

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