Microprocessor Based Single Phase Speed Control of Induction Motor Drive

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Abstract- **The old mechanical drives and traditional drives were replaced with the electrical drives and the demand for the automated drives existed which lead to develop the electrical drives. The power drives are widely used in the industrial control applications. The various control strategies are used to control the drives but the development in semiconductor technology boosted the use of power devices in the drives. The demand for compact, reliable and automated drives existed and the development of drive has taken place in the right direction in variety of applications like power supply, tractions, vehicles, etc. which has no boundaries for the development. Personal computer made the control techniques easy but beyond that the microprocessor based single phase drives are demanded in the remote areas. Demand of control of power existed for many years which led early development of drives. Power handling capabilities and switching speed of power drives has been increased with development in semiconductor technology.**

The current topic deals with the design of single phase induction motor drive using the microprocessor. The drive is designed with the inverter based circuits. The firing pulses for the transistor inverter is done by using the PWM pulses generated by the microprocessor. The required PWM signal generation software is written in assembly language. The single phase supply is converted in to dc and then using the transistor inverter AC signal, single phase supply is generated. The Buffer is used for the driving and amplification purpose. The snubber will help to reduce the transients in the circuits or surge pulses in the firing circuit. The speed of the motor is varied by varying the width of the firing pulse. The speed of the drive is measured using tachogenerator. The various parameters are measured and compared simulated results.

Keywords- **Microprocessor Based Induction motor, Pulse Width Modulation, Single Phase induction Motor control, Inverter Driver, Snubber, Speed control of induction motor, Microprocessor.**

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I. INTRODUCTION

In the past DC motors were used for control applications but due to certain disadvantages, these were replaced by the induction motors. As the industrial revolution took place in 18th century more and more industries started using the induction motors for process control. With the advent of technology, the demand of precise control of process was needed and it is possible with the help of computer [1,2] and microprocessor, as this is inexpensive and can work in abnormal, remote location, etc. The development of electric drives took place as the demand of control of electric motor drive system and industrial control existed. Many industrial applications now a day requires variable speed drives, smooth operation, etc. even in poor circumstances, such as adjustable speed drives [3]. Now a days control engineering become a formal discipline, where more and control systems have designed using induction motors and today induction motor represents one of the most important control components of the system. In last two decade extensive research took place in reduction of line harmonics in the induction drives [4]. Significant progress in power devices as MCT, SCR, GTO, Power transistors, power MOSFETS, etc. is possible to design reliable and flexible drive systems for the induction machines [5], so sophisticated controlled techniques based on the microprocessor and microcontrollers [5-8] picked up the significant development in induction drives. It is possible to design high performance drives for induction motor using the microprocessor.

Now a days the various estimation techniques and control schemes are gaining importance and more attention is paid towards the development of such drives. The literature also helping and providing the importance to these drive and its techniques. Recently the growth of development in the technology is shooting with the past changes. The PC based development of induction motor drives boosted with software that helps to put best solution for the drive. The microprocessor based drive also helps to design a compact low power supply which makes its suitability in the industrial and remote applications.

II. SYSTEM DESIGN DETAILS AND CONTROL OF DRIVE

Fig.1 shows an overall complete detailed system diagram to control the inverter fed single phase induction motor drive. The control electronics includes an improved method of PWM control. There is an instantaneous microprocessor based control. The improvements in the controlled PWM method minimizes both peak transistor current and motor loss with better sinusoidal waveforms. The system control generates the appropriate frequency and current amplitude signal by using the microprocessor. The Fig. 2 shows the single phase transistor bridge inverter. The firing of transistor sequence is 1-4 & 2-3 which provides Power to the induction motor.

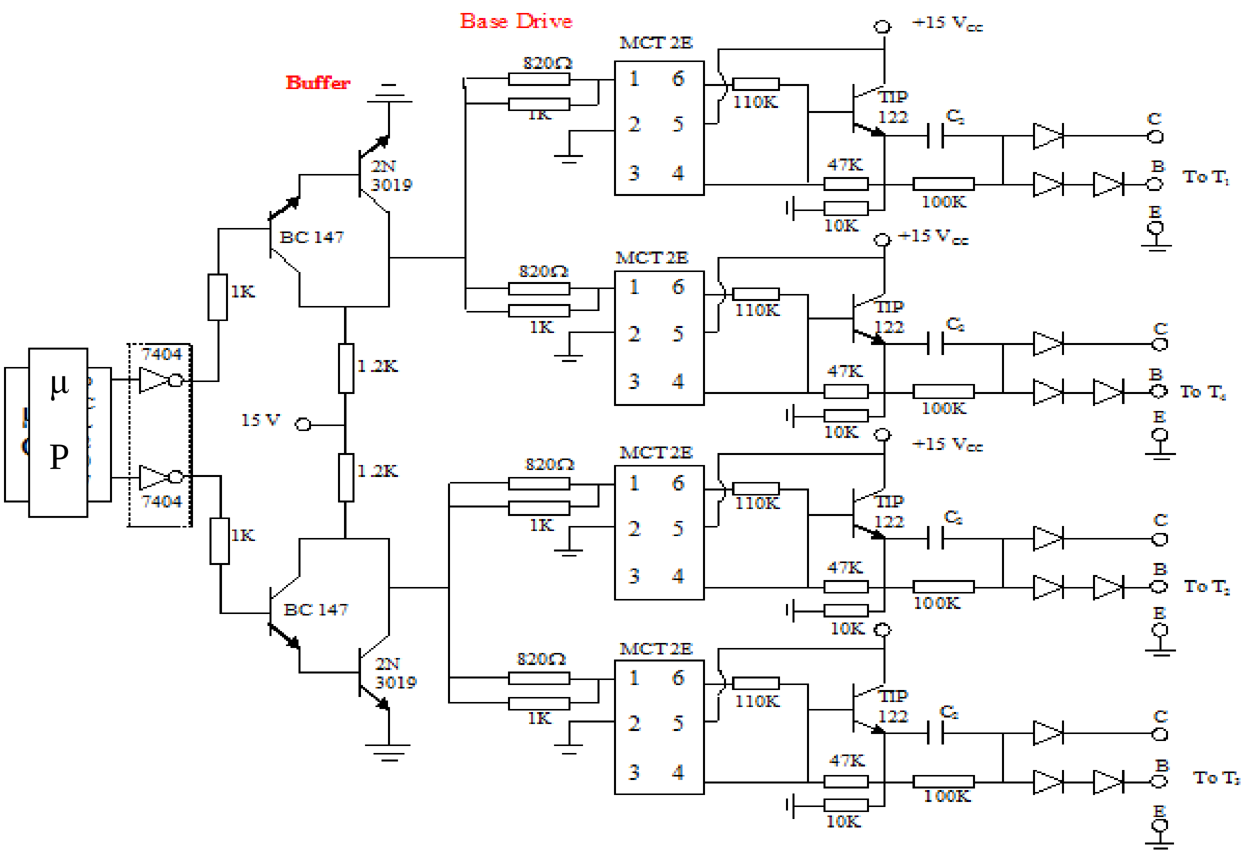


Fig. 1 Complete Circuit Diagram of Induction Motor Drive

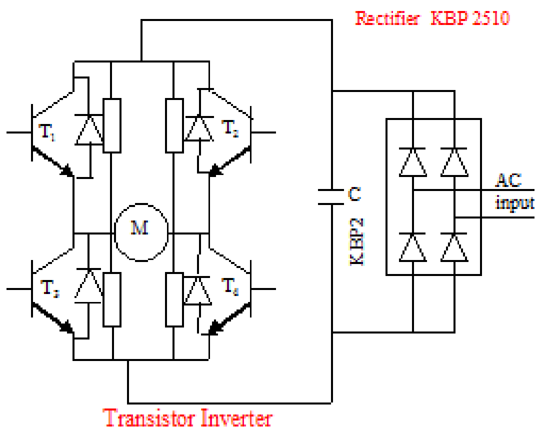


Fig. 2 Transistor Inverter Bridge

The PWM signals from the microprocessor are given to the inverter, The buffer will help to boost the current capability required fro driving the transistors, The isolator will isolates the power circuit from the control circuit. TIP 122 configurations will help to provide proper phase and amplification however, these signals are used as base signals for firing the transistor in the bridge, Based on proposed control system the microprocessor is used as control element. The microprocessor provides the digital control data either high or low at its port. The period of remaining the data high is controlled by using the assembly language programming. The fixed interval of which the pulse remains high at the port and also remains low for fixed interval of time. The Time period over which is kept high depends on the delay time. This output of the port is used to drive the base of power transistor and hence the proportional power is controlled by using this technique. The proportional power gives open -loop control scheme has been formulated for the speed control of the induction motor drive feed formation from the voltage source inverter. The speed of the induction motor depends on the pulse width given to the base of the power transistor. The larger the pulse width more the speed and vice versa. The closed loop technique is not employed in this because the microprocessor if self controls the pulse width through programming and hence speed is controlled.

A. Rectifier Module

A rectifier module is a combination of diode bridge and capacitor bank. The bridge is formed by combination of 4 power diodes (1N4006) which converts AC signal to DC. A dc filter capacitor bank is connected across the input to the inverter and serves to filter the input voltage and provide a low impedance path for the high frequency currents generated by the inverter during PWM switching.

B. Snubber design

The snubber circuit consists of simple method using register, capacitor in parallel with power module and parasitic inductance is placed in series with power module shown in fig 3. The snubber circuit is effective during the turn-off of the transistor and snubber inductance is effective during turn-on.

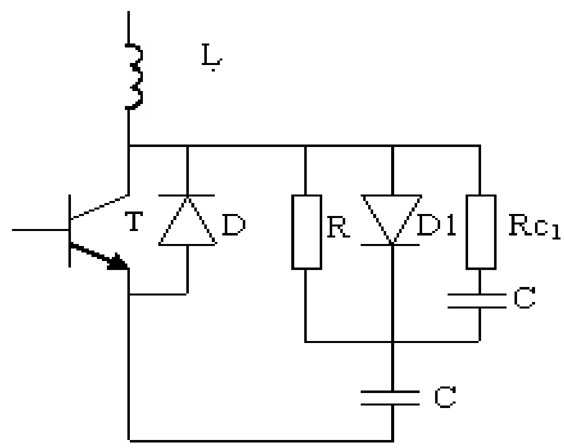


Fig. 3 Circuit diagram of snubber

Snubbers are required because transistor have safe operating area limitations during turn-off to avoid catastrophic second breakdown failure. With inductive load transistor transfers the load current to the opposite oncoming feedback diode in same phase of inverter. When the transistor current falls opposite diode can begin to conduct load current. The snubber inductance in the inverter phase now generate an overshoot voltage which appears across the transistor during the transistor fall time and collector voltage begins to rise. The snubber capacitor begins to charge. The charging current is from the transistor charging the capacitor to be maximum. At the same time feedback diode begins to conduct and current is transferred from snubber to diode. The choice of snubber capacitance limits the peak overshoot which helps to reduce turn-off losses.

III. SIGNAL CONDITIONING

A. Speed Sensing

The basic block diagram of speed sensing is shown in Fig.4. The opto-interrupter device is used for speed measurement with the help of which two pulses were generated within one revolution of motor. These pulses were feed to the frequency to voltage converter (F to V). The output of the F to V converter is scaled in between 0 - 5 V for speed range of 0-1400 rpm, which is read through the A/D converter and scaled properly through software to display correct speed. The response of speed sensor is non-linear at initial stage (i.e. at very low speed) and then it follows linearity.

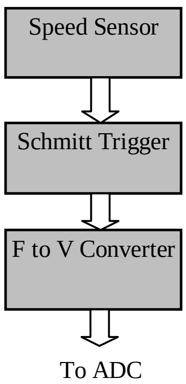


Fig. 4(a) Block diagram of speed sensing circuit

B. AC Voltage Sensing

The AC voltage measurement was carried out by using the peak detector circuit. The variation in the voltage of the peak detector according to the line voltage changes fed to one of the ADC channel and is further converted to actual voltage by scaling the output voltage of peak detector through software.

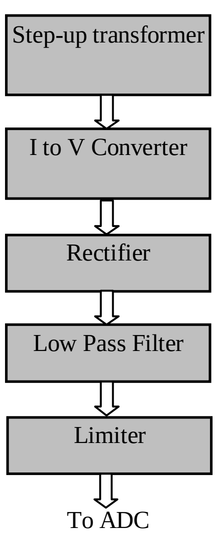


Fig. 4(b) Block diagram of the current sensing circuit**.**

IV. FLOWCHART OF DEVELOPED SOFTWARE

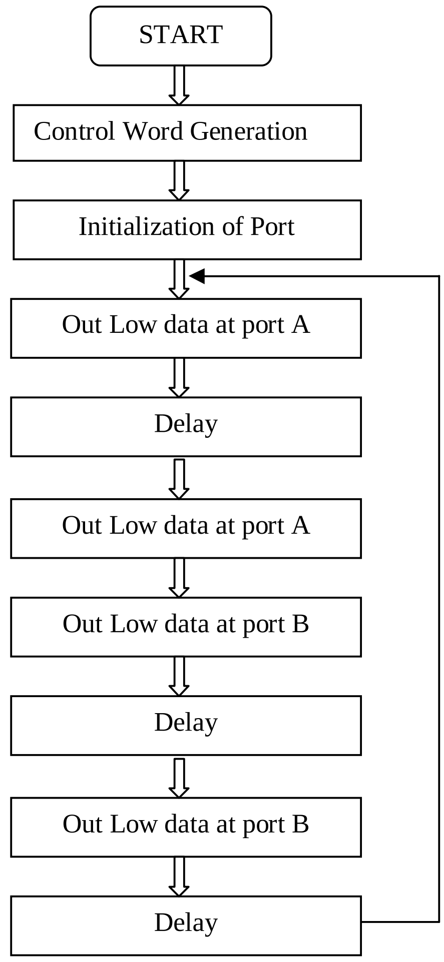


Fig. 5 Flow chart of pulse generation

C. Current Sensing

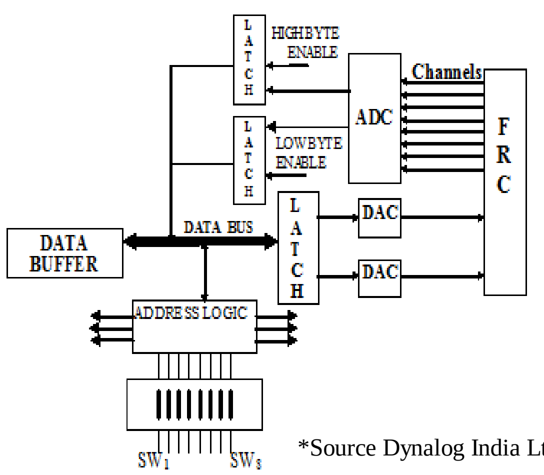
For current measurement simple technique is used, which consists of step up transformer whose primary is short-circuited by the shunt wire and the current through the shunt is given to the motor. The voltage drop across the shunt wire is proportional to the current passing through it, which is the current of the motor and secondary voltage is proportional to the motor current. The output voltage varies from 0 to 5 volt for variation of current from 0 to 5 ampere. There is linear relationship between input current and output voltage. The scaling is only essential.

A. Steps in flow chart generation

1. Initilization of ports of 8255
2. Clear port
3. Keep port A pin low for given delay
4. Store data in any register and decrement till it become zero.
5. Make port A pin high and keep it high for given delay
6. Store data in any register and decrement till it becomes 1
7. Continue this process.
8. For changing speed, vary pulse width at port A.
9. Continue with the changed width and speed.

V. PLC 207 DAC-ADC INTERFACING CARD

The PLC-207 AD/DA card is used for ADC or DAC purpose [9]. The card I low cost high performance analog interface card shown in fig. 6 which uses successive approximation method. This provides 25 thousands samples per sec. acquisition rate It is a 12 bit card with accuracy of 0.015 %. This provides fast output channel settling time 30 µS with high accuracy. It can accept 8 inputs and 12 monolithic multiplying DA output channel with 0-5V. The PCL207 provides powerful software driver which is very easy to use for routine programes.



*Source Dynalog India Ltd.

Fig. 6 Block diagram of the PCL207 Card

VI. SYSTEM PERFORMANCE

The system performance is tested for constant load and it is found that the speed of the system remains constant. With the help of the tachometer the speed of the system is measured at constant load. Keeping the constant load the pulse width of the firing of the transistor is varied with the help of the software. It is found that if pulse width is more the speed of the drive is also more and vice-versa. However, the system is open loop and any change in the load that may deviate from the desired speed. This system is quite suitable for the constant speed operations. The tachometer reading shows that there is no deviation of speed limits of the drive at least as well as highest pulse width. The performance is studied with the help of simulated technique for the different pulses. The fig.7 shows the graph of speed Torque characteristics for the different PWM schemes. From the graph it is seen that initial starting torque is higher and as the speed increases the torque decreases which gives strong support for the designed drive. The similar characteristics behaviour is observed with the simulation characteristics. After comparison it is found that the results of speed-torque characteristics of the designed drive using microprocessor gives the result almost similar performance to that of simulation. The speed efficiency characteristics are shown in the fig.8 for simulation drive as well as for designed drive. From the characteristics it is found that experimental drive has less efficiency due to the losses in the machines otherwise designed drive and simulated drive efficiency remains almost same.

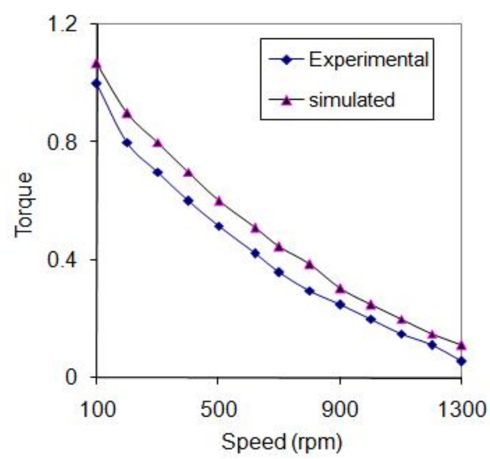


Fig.7 Speed -Torque characteristic for the simulated and experimental drive.

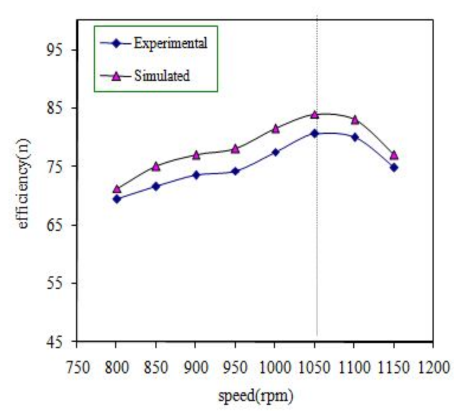


Fig.8 Speed - Efficiency characteristics for the simulated and experimental drive.

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