# CHAPTER 4

## BLOCK DIAGRAM OF PROPOSED SYSTEM

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page No</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Introduction</td>
<td>73</td>
</tr>
<tr>
<td>4.2</td>
<td>Three Phase Full Bridge Rectifiers</td>
<td>73</td>
</tr>
<tr>
<td>4.21</td>
<td>The DC Bus Bulk Capacitor</td>
<td>73</td>
</tr>
<tr>
<td>4.3</td>
<td>Three Phase Full Bridge Inverter</td>
<td>75</td>
</tr>
<tr>
<td>4.4</td>
<td>Control Circuit</td>
<td>77</td>
</tr>
<tr>
<td>4.5</td>
<td>Speed Sensing Unit</td>
<td>78</td>
</tr>
<tr>
<td>4.6</td>
<td>Speed Selector Switch and Display Unit</td>
<td>78</td>
</tr>
<tr>
<td>4.7</td>
<td>Isolation Circuit</td>
<td>78</td>
</tr>
<tr>
<td>4.8</td>
<td>DC Regulated Power Supply</td>
<td>79</td>
</tr>
<tr>
<td>4.9</td>
<td>Out Put Filter</td>
<td>79</td>
</tr>
<tr>
<td>4.10</td>
<td>Conclusion</td>
<td>80</td>
</tr>
</tbody>
</table>
CHAPTER 4

BLOCK DIAGRAM OF PROPOSED SYSTEM

4.1 Introduction

This chapter describes the block diagram of the microcontroller based controller for three phase induction motor and its detail. The block diagram of proposed system is as shown in Fig. 4.1. The details of each block such as three phase full bridge rectifier, the bulk capacitor, three phase full bridge inverter, control circuit, speed sensing unit, speed selector switch, display unit, isolation unit, dc regulated power supply and output filter are discussed as follows.

4.2 Three Phase Full Bridge Rectifiers

In this process a three phase AC voltage is converted into DC voltage. In order to obtain the essential DC voltage for the inverter, a three phase diode bridge rectifier has been used. The bridge rectifier consists of six set of power diodes. They are connected in three legs and each leg consists of two sets of diodes. Each set of diode consists of two diodes connected in parallel combination to enhance the rating of the each set of diode. To reduce ripples and to have a smooth DC at the input of IGBT inverter, the DC link capacitor filter has been used at the output of rectifier. Therefore, a filter stage is required. Primarily, this consists of a large capacitor bank as shown in Fig. 4.1.

4.21 The DC Bus Bulk Capacitor

To reduce ripples in the circuit a DC link capacitor filter is used. Electrolytic capacitors are used to smooth the dc bus voltage. In the proposed scheme the bridge rectifier is used to provide the dc voltage to the inverter circuit. For a given load, a larger capacitor will reduce ripple but it costs more and creates higher peak currents in the supply.
Fig 4.1 Block Diagram of the System
4.3 Three Phase Full Bridge Inverter

The 3-phase induction motor is connected to a 3-phase inverter bridge as shown in Fig. 4.2. The power inverter has six switches that are controlled in order to generate 3-phase AC output from the DC bus. The full bridge inverter is designed by using six IGBT’s $I_1$, $I_2$, $I_3$, $I_4$, $I_5$ and $I_6$ with anti-parallel diodes across each IGBT. IGBT’s pairs $I_1-I_6$, $I_3-I_2$ and $I_5-I_4$ comprise the first, second and third leg respectively. After every 60° one IGBT is fired in the sequence of 1, 2, 3, 4, 5, 6 and 1. At any instant of time two IGBT switches will be conducting, that is one from upper group and one from lower group. During the commutation period three IGBT switches will be conducting, one from upper and two from lower switches or one from lower and two from upper group. PWM signals generated from the digital signal controller, controls these six switches. Switches $I_1$, $I_3$ and $I_5$ which were connected to positive DC, are called upper switches. Switches $I_2$, $I_4$ and $I_6$, connected to negative DC, are called lower switches. The amplitude of phase voltage is determined by the duty cycle of the PWM signals. The switching pattern produces a rectangular shaped output waveform that has harmonics. The inductive nature of the motor’s stator windings filters the non sinusoidal waveform to produce a three phase sine wave with negligible harmonics. When switches are
turned off, the inductive nature of the windings oppose any sudden change in direction of flow of the current until all of the energy stored in the windings is dissipated. To facilitate this, fast recovery diodes are provided across each switch. These diodes are known as freewheeling diodes.

If both outgoing and incoming IGBTs remained ON simultaneously during turn-on and turn-off switching, there would be a short circuiting. To avoid this dead-time is given between switch-on and switch-off of IGBTs of the same leg. During dead time no IGBT of the same leg is conducting. The dead time for this inverter is 2μ Sec.

In this work, IGBT’s are used as switches for the inverter because it has more advantages over other semiconductor devices such as BJT and MOSFET, they are as follows:

- IGBT is basically a hybrid MOS gated turn on/off bipolar transistor that has the advantages of both MOSFET and BJT.
- IGBT has high input impedance of MOSFET and conduction characteristics of BJT.
- IGBT has high current density than that of MOSFET or BJT.
- Its input capacitance is less than that of MOSFET.
- Control part of IGBT is similar to that of MOSFET and output part is similar to that of BJT.
- IGBT is voltage controlled device, but BJT is current controlled device.
- IGBT has high power levels and high operating frequencies but MOSFET has low power ratings, hence used in low power applications.
- On state losses in IGBT is low as compared to MOSFET
- IGBT has approximately flat temperature co-efficient.

The IGBTs are protected by snubber circuit. The snubber circuit does the following functions

- Reduces voltage/ current spikes
- Limits \( \frac{d}{dt} \) and \( \frac{d_i}{dt} \)
- Shapes the load line to keep it within the safe operating area
- Reduces total loss due to switching
- Reduces electromagnetic induction EMI by damping voltage

There are many different kinds of snubbers, but two most common ones are the Resistor-Capacitor (RC) type and Resistor-Capacitor-Diode (RCD) type snubber. In the present work the RC type snubber is used which limits the peak voltage.

**4.4 Control Circuit**

The control circuit of the proposed scheme consists of a Digital signal Controller (DSC) dsPIC30F2010. DSC controls power switches in the inverter circuit. The module has six pulse width modulation (PWM) output channels numbered PWM1_H/PWM1_L through PWM3_H/PWM3_L. The six output channels are grouped into high/low numbered pairs, denoted by the suffix H or L, respectively. This module contains 3 duty cycle generators, numbered 1 through 3. The duty cycle of each PWM can be varied individually to generate a 3-phase AC waveform. To derive a varying 3-phase AC voltage from the DC bus, the PWM outputs are required to control the six switches of the power inverter. This has been done by connecting the PWM outputs to three IGBT drivers (TLP-250). Each driver takes one PWM signal as input and produces one PWM output. These signals are used to drive one half bridge of the inverter: one to the upper switch, the other to the lower switch. The driver also adds a fixed dead time between the two PWM signals.

According to the requirement, a software program is developed and is embedded in to the digital signal controller dsPIC30F2010 for the necessary action. The controller circuit essentially takes the reference speed and actual speed of the motor into account. Depending upon the difference between the reference speed and actual speed, the DSC decides the frequency of gate pulse of IGBT’s in the inverter in order to bring the motor speed to the
desired or set speed. The controller also decides the instant timing of the gate signal to be given to the IGBT’s, in order to avoid the overlapping in conduction of incoming and outgoing IGBTs. Because the overlapping in conduction leads to the short circuiting of dc supply, causing a dangerous current flow through the IGBT’s. To avoid this dead time is added.

4.5 Speed Sensing Unit

In the proposed control system a non-contact type sensor has been used to measure the actual speed of the drive system. In this an ILED-Photodiode combination is used to sense the speed of the drive system. The input to the ILED-photodiode system is 5V. The disk fixed on the shaft of the motor has one blade. The blade is passed through the gap between the ILED-photodiode systems thereby restricting the path of light falling on to the photodiode. The output pulse generated is used to switching action of the transistor. The output of the transistor is given to controller in which the number of times of the restriction of light per second is sensed and then it multiplied by sixty in order to get revolution per minute. The RPM displayed has an accuracy of +/-15 RPM.

4.6 Speed Selector Switch and Display Unit

The motor speed can be set and it can be changed with the help of speed selector switch in steps of 20 RPM. In each step the signal is given to the pin number 16 or 17 to increase or decrease the speed respectively. The desired speed is achieved with an accuracy of +15 or -15 RPM. The display unit contains 16-channel, 2-lines liquid crystal display. The user can view the speed of the motor drive system in rpm and this is displayed on the LCD through port E of DSC.

4.7 Isolation Circuit

The isolation circuit provides isolation between the power circuit and the control circuit. In the proposed controller an optocoupler TLP250 has been used to isolate the gate
drive circuit and the IGBT’s based power circuit. The optocoupler consists of an Infrared Light-Emitting Diode (ILED) and a silicon phototransistor. The input signal is applied to the ILED and the output is taken from the phototransistor. The use of optoisolators ensures that power ground (P_GND) and control ground (D_GND) are separated. This means that development tools, such as MPLAB can be safely connected to the system while it is connected to the AC supply.

4.8 DC Regulated Power Supply

In the proposed control system the required DC voltages are:

- +5V for DSC controller IC
- +5V for speed sensor and optocoupler isolation TLP250
- +12V for gate firing pulses of I₂, I₄ and I₆
- +12V each for gate firing pulses of I₁, I₃ and I₅.
- +5V for liquid crystal display

In order to produce above said power supplies, a step down transformers of voltage ratio 230/12-0-12 has been used. Four LM 7812 voltage regulators were used to fire six gates of the inverter switches. Single LM 7805 voltage regulator is used to get a supply of +5V which is essential to operate dsPIC, LCD and speed sensing unit. AC voltage of each secondary winding is passed through the respective diode bridge rectifier. The rectified voltage is fed to the corresponding LM 7812 /LM 7805 voltage regulator to get required voltages.

4.9 Output Filter

Output of a three phase inverter contains harmonics and they are in non sinusoidal voltages in nature. These voltages causes harmful effect on motor performance, in order to avoid these effects, a filter unit has been connected in between motor and inverter output terminal. The passive filter is used in the present work because of the following reasons.
- Passive filters have high Q factor characteristics, hence low damping at resonant frequencies.
- Cost is less as capacitors, inductors and resistors are used.
- Operating losses are reduced.

4.10 Conclusion

In this chapter the block diagram of the complete proposed closed loop volts hertz control system and its working is explained. The block diagram has single phase full-bridge diode rectifier, dc bus bulk capacitor, three phase full bridge IGBT based inverter, control circuit, speed sensing unit, isolation circuit, IGBT drive circuit, speed selector switch, display unit and DC regulated power supply. The working of each component of the block diagram is discussed in detail.