CHAPTER - III

SYSTEM DESIGN

3.1 INTRODUCTION

Microcomputer applications in measurement and control system are extensively spread in recent years [1-13] because of their accuracy in measurement and control. With the development of low cost high performance computers, the computer plays the main role of feedback control by computer algorithm and measurement. A single-chip microcomputer usually contains a CPU, one chip clock ROM, RAM, I/O and useful interface circuit such as timer or an A/D converter. As its bus lies inside the chip, it is comparitively immune to the external noise. So, it is very suitable use for a PC based systems for simple industrial equipment control and measurement [14,15].

In the present work, an attempt has been made to develop a computer based system for measuring various instantaneous performance data such as power factor, horse power, percentage efficiency and speed of a squirrel-cage induction motor operating from no load to full load. In the conventional method of measurement, one has to perform different tests, note various electromechanical meter reading like Wattmeter, Ammeter, Voltmeter and Tachometer. Then finally calculation will be carried out. In fact the method is laborious as well as time consuming and continuous information under operating conditions cannot be readily obtained which is of prime importance especially when the load on the motor is continuously changing.

In the present chapter, typical data acquisition system was designed and developed in the laboratory which consists of individual sensors with necessary signal conditioning, multiplexing, data conversion, data handling, associated transmission, storage and display system. The sensing circuits for speed and current gives the observations for respective parameters. To perform the further computations from these parameters and to display the results in graphical form on computer monitor, a menu driven system software has been written in higher-level language. With the present system the characteristics of motor like, torque-speed, efficiency-speed etc. can easily be displayed on computer.

3.2 BLOCK DIAGRAM OF THE SYSTEM

In order to optimize the characteristics of a system in terms of performance capability and cost, the relevant subsystems may often be combined. The analog data is generally acquired and converted to digital form for the purpose of processing, transmission, display and storage. Processing may consists of large number of operations, from simple comparison to the complicated mathematical manipulations. The schematic block diagram of a developed data acquisition system is shown in Fig. 3.1.

The number of parameters are to be sensed which are required to test the performance of the motor by performing various calculations by using sensed data. The system is designed to meet the required specifications. The characteristics of the data acquisition system depends upon the properties of the analog data itself and on the processing to be carried out. The important factors that decides the configuration and the subsystems of the data acquisition systems are:

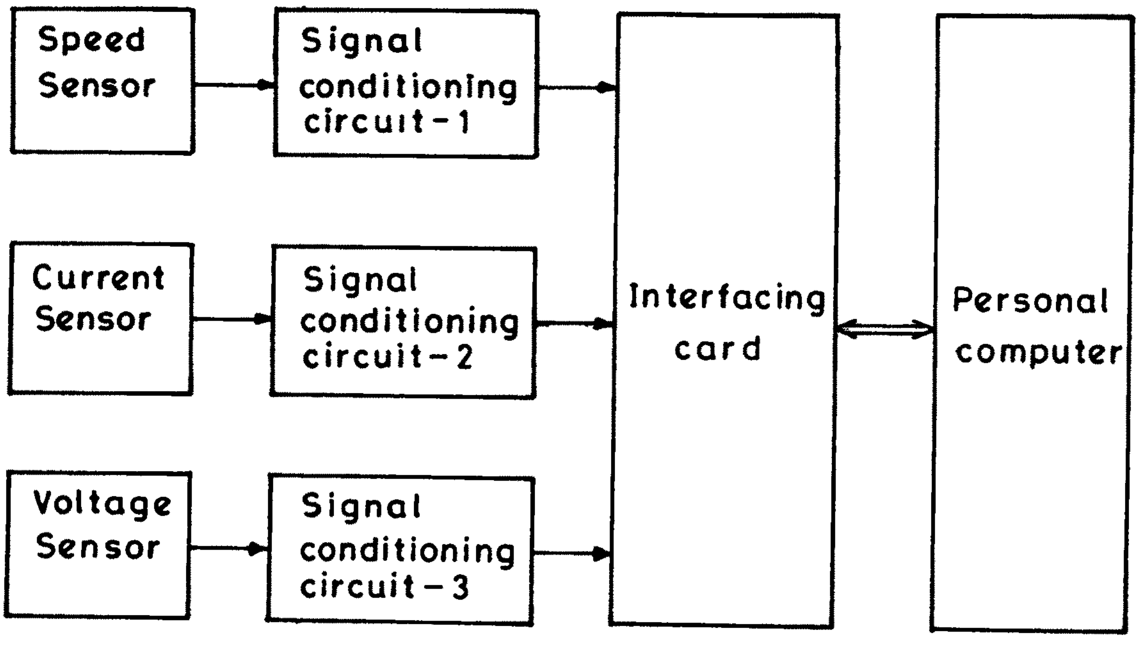


FIG. 3·1 – BLOCK DIAGRAM OF THE SYSTEM.

1. Resolution and accuracy.
2. Number of channels to be monitored.
3. Sampling rate per channel.
4. Signal conditioning requirement of each channel .
5. Cost.

By considering all above characteristics the optimized system was designed and developed in the present work. Its performance testing and calibration etc. was done by using standard laboratory equipment for precise measurement of motor parameters.

3.3 HARDWARE DESCRIPTION

To develop the present system, the complete hardware may be divided into following different parts:

1. Interfacing card.
2. Signal conditioning card.

3.3.1 Interfacing Card

Interfacing card consist of IBM PC/XT/AT compatible ADC with 8-single ended input channels and DAC with single output channel. The block diagram of the interfacing card is shown in the fig. 3.2. The base address is selected by the DIP switch. When the software routine address matches with the DIP switch address, the card is enabled. The reference voltage generator produces the desired reference voltages which are jumper selectable.

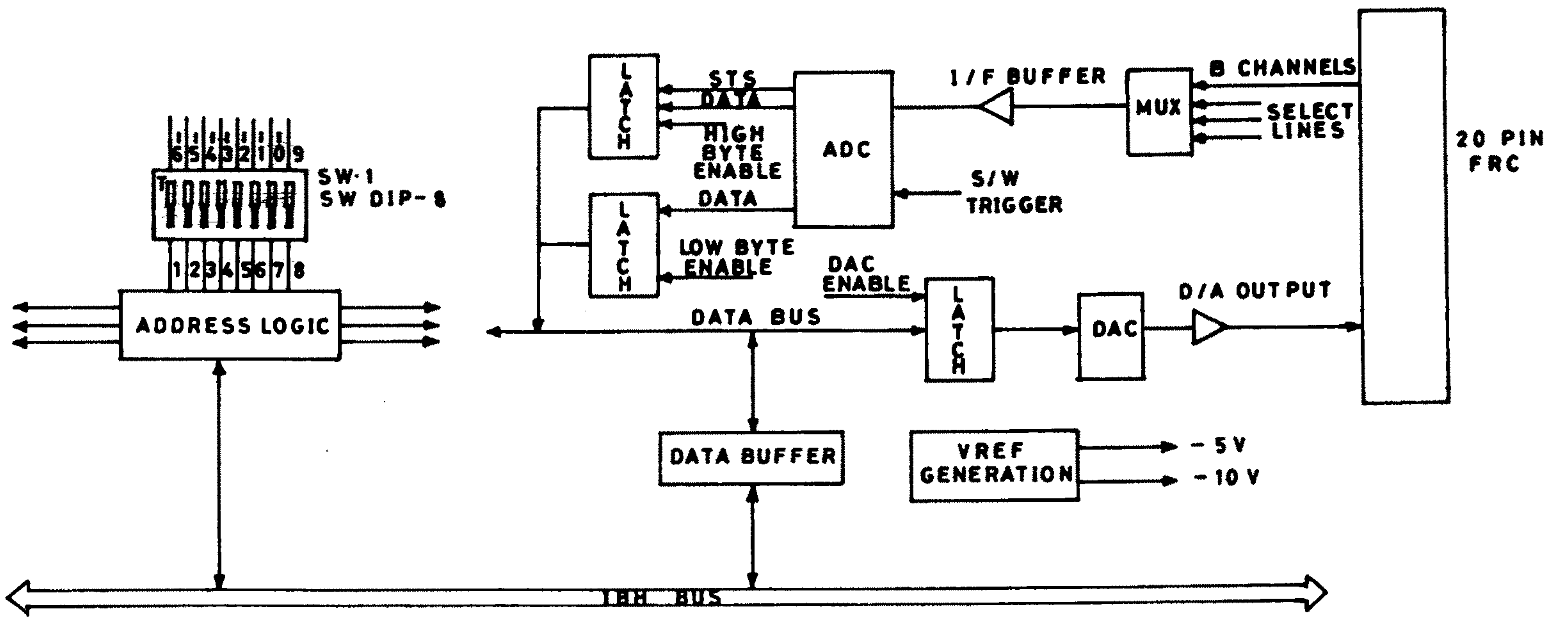


FIG. 3·2 - BLOCK DIAGRAM OF INTERFACING CARD.

In the D/A operation, the digital input from the PC-bus is fed to a latch through the data buffer. The latched digital value is fed to the DAC logic for D/A conversion. The analog output is fed to a buffer and finally to 20 pin FRC connector.

In the A/D operation, any one of the 8 channels present on the 20 pin FRC can be selected by the MUX. For impedance matching the input signal is buffered and then fed to the ADC. The ADC can be software triggered by outputting the required data through the specific address register. The converted data can be read through two latches, one containing the higher byte and the other, lower byte. The data is fed to the IBM-PC bus through the data buffer.

The correct signal connection is the important factor in the system development to assure the system sends or receives data without any malfunctioning since most of the data acquisition applications involves voltage measurement correct signal connection is necessary to avoid damage to the equipment.

3.3.1.1 Analog Input Connection

The interfacing card supports an 8-single ended analog configuration. This configuration has only single wire for each channel. The voltage of this wire to be measured is referred to as common ground to the card. A signal source without the local ground is called as a floating source. It is easy to connect a single ended channel to a floating signal source. The connection of ADC channel is shown in the fig. 3.3.

3.3.1.2 Analog Output Connection

The interfacing card provides the one Digital to Analog converter output channel. The card internally generated precision -5V / -10V reference is used to generate 0 to +5V / +10V D/A output. The digital to analog signal converted should be connected as shown in Fig. 3.4.

3.3.1.3 Base Address Selection

Some of the PC peripheral devices and interface cards are controlled through input/output ports. These ports are addressed using the I/O port address space.

In the present card an 8 way DIP switch is present on board out of which sw1-sw6 is used for base address selection and sw7 and sw8 are used for software trigger selection.

The interfacing card requires 16 consecutive address locations into I/O space. Valid addresses are from Hex 000 to Hex 3F0. The addresses can be changed before installing the card in the computer. The addresses can be selected from the address Table 3.1

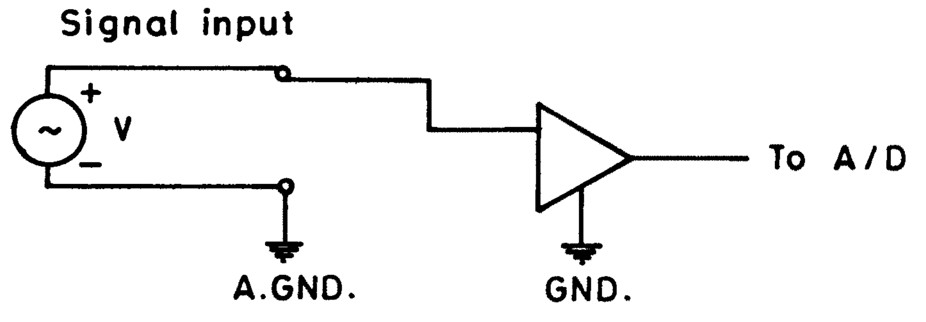


FIG. 3·3 – ANALOG OUTPUT CONNECTION.

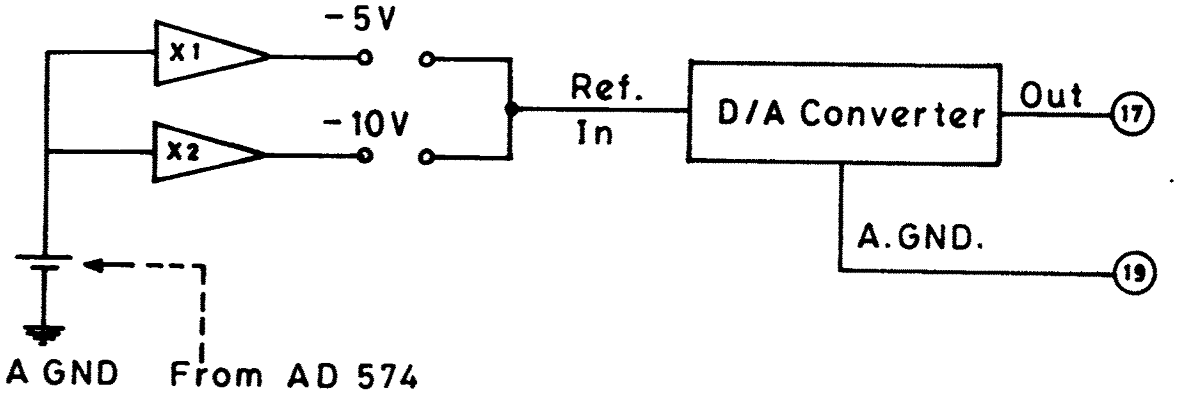


FIG. 3·4 – REFERENCE VOLTAGE.

Table 3.1

I/O Address Range (Hex)	**Switch Position**					
	1	**2**	**3**	**4**	**5**	**6**
	A_9	**A_8**	**A_7**	**A_6**	**A_5**	**A_4**
000-00F	0	0	0	0	0	0
100-10F	0	1	0	0	0	0
.						
.						
.						
200-20F	1	0	0	0	0	0
210-21F	1	0	0	0	0	1
220-22F	1	0	0	0	1	0
.						
.						
.						
300-30F	1	1	0	0	0	0
3F0-3FF	1	1	1	1	1	1

For switch : ON = 0; OFF = 1

3.3.2 Signal Conditioning Card

Within signal conditioning card there are three different signal sensing subsystems which are used to sense the speed, current and supply voltage to the machine.

3.3.2.1 Current Sensing Circuit

The current drawn by the any electric machine is the important parameter. To measure the current the following circuit configuration was used and which is shown in Fig. 3.5. To sense the current drawn by the motor simple step-up voltage transformer is used. The arrangement of the sensing circuit is shown in Fig. 3.6. When motor starts the current will drawn by the motor inproportion of applied load. This current passes through the shunt wire which develops the potential proportional to motor current. This voltage is the primary voltage of transformer which induced corresponding voltage in secondary which is proportional to the motor current. This secondary voltage of the transformer is scaled by using Op-Amp (741) amplifier as shown in the Fig. 3.7.

3.3.2.2 Speed Sensing of Motor

In high performance drives of induction motors accurate speed measurement is essential. The conventional method of speed measurement is speed detectors attached to motor shafts. Such as tachometers, but they need extra considerations for maintenance, layout, mechanical problems etc. of the induction motors. Therefore it is desirable to detect rotor speeds without tachogenerators. In the present work the speed measurement system was developed with slotted optocoupler as a speed sensor. The block diagram of the speed sensing circuit is given in Fig. 3.8.

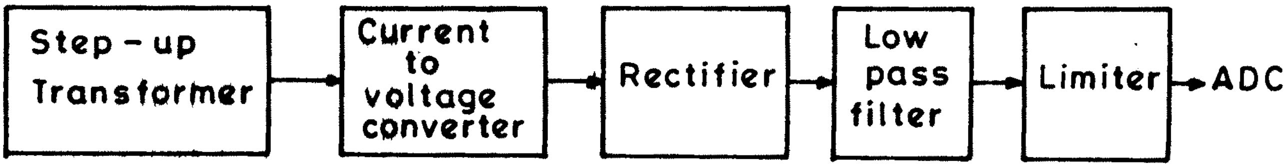
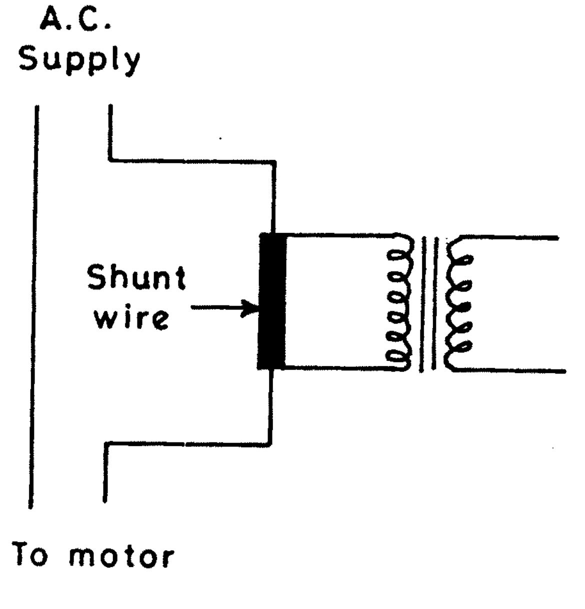


FIG. 3·5 - BLOCK DIAGRAM OF THE CURRENT SENSING CIRCUIT.



CURRENT SENSING ARRANGEMENT

FIG. 3·6

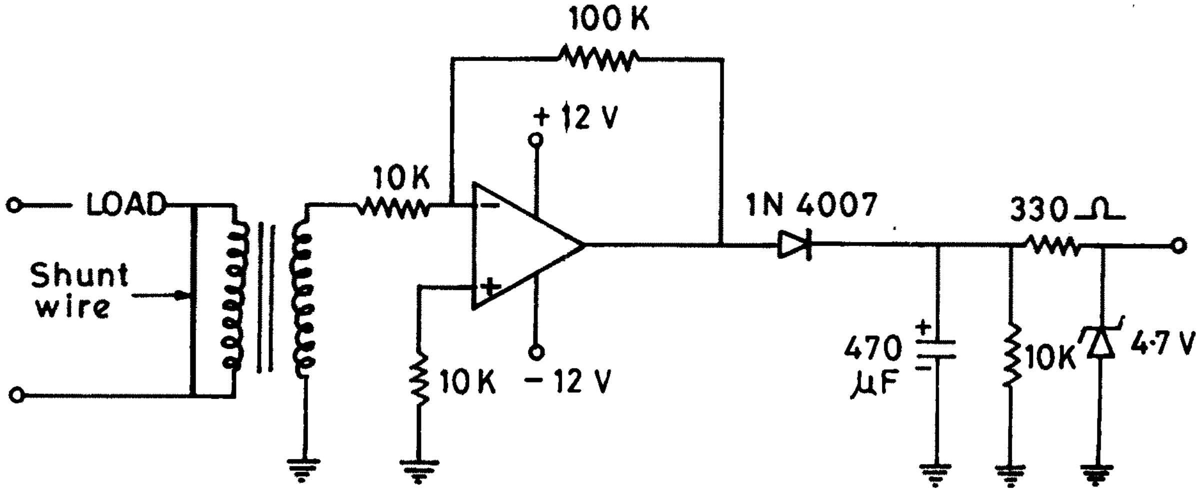


FIG. 3·7 – CURRENT SENSING CIRCUIT.

The slotted optocoupler ACT - 8 provides the pulses corresponding to number of times the light cut per revolution. In the present experiment the metal strip is attached to the shaft of the motor which gives two pulses per revolution. These pulses are given to Op-Amp 741 based comparator to generate the square pulses. The complete circuit diagram is given in Fig. 3.9. The output of the comparator must be limited to 5 volts. This is achieved by using the Z4.7 V Zener diode. These pulses are counted for fixed time and speed is calculated by using the relation.

$$RPM = [\ Count / (Y_E - Y_S)\ ] \times 60 \qquad \text{----------} (3.1)$$

Y_E -The end time

Y_S - The start time

3.3.2.3 Voltage Measurement

The measurement of line voltage is very important in monitoring electric machine. In the present work attempt has been made to measure the voltage by using the peak detector circuit. The detail circuit diagram of voltage measurement unit is given in the Fig. 3.10. The variation in the voltage from 180V to 250V corresponding change in the peak detector is given to one channel of Analog to Digital converter circuit (or ADC card). The output voltage of ADC converted into actual voltage through the software.

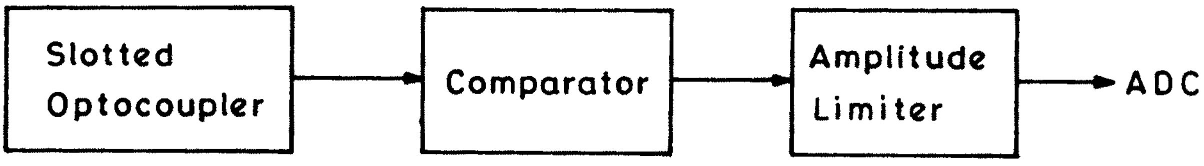


FIG. 3·8 – BLOCK DIAGRAM OF THE SPEED SENSING CIRCUIT.

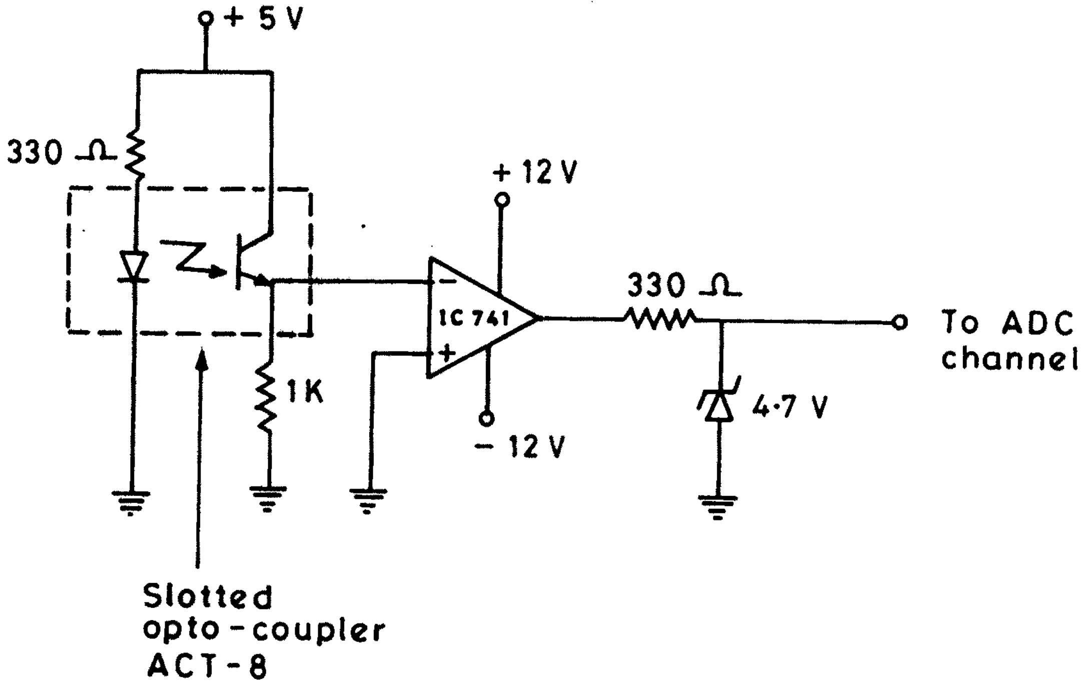


FIG. 3·9 – SPEED SENSING CIRCUIT.

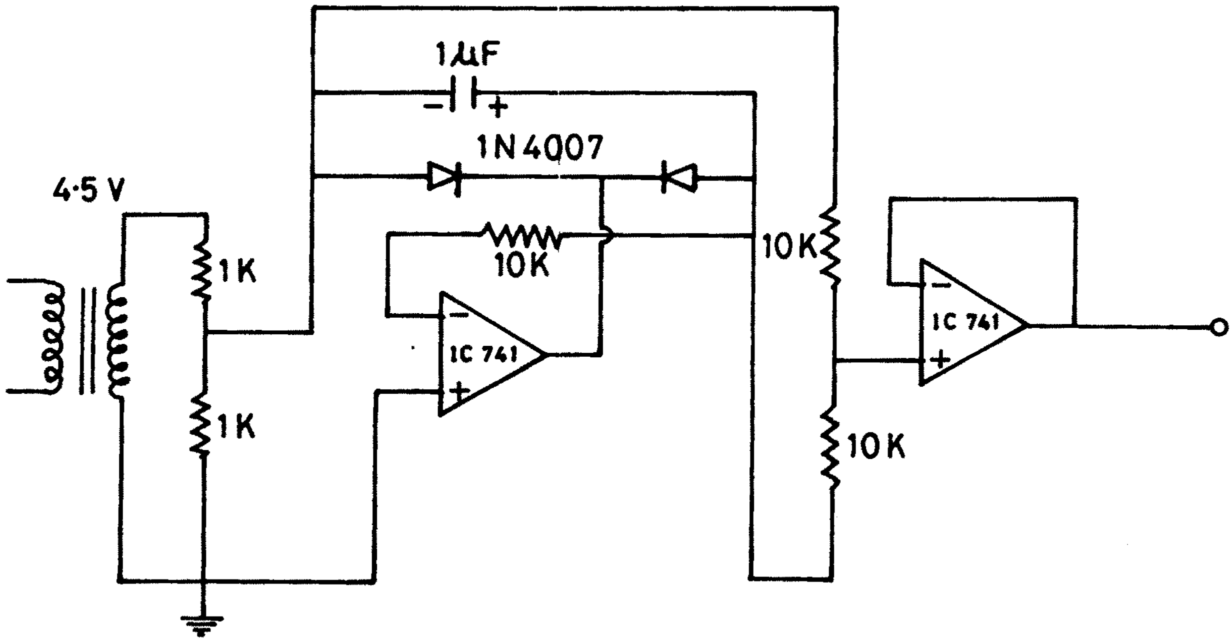


FIG. 3·10 - VOLTAGE SENSING CIRCUIT.

REFERENCES

1. T. Ohmac, T. Matsuda, T. Suzuki, N. Azusawa, K. Kamiyama and T. Konishi, " A microprocessor-cotrolled fast response speed regulator with dual mode current loop for DCM drives," IEEE Trans. Ind. Appl. Vol. IA-16, No. 3, pp. 388-394, 1980.

2. K. Ohishi, M. Nakao and K. Miyachi, " Microprocessor-controlled dc motor for load-insensitive position servo system", IEEE Trans. Ind. Electron., Vol. IE-34, No. 1, pp. 44-49, 1987.

3. M.R. Khare and G.N. Garud, " Microprocessor based thyristerized control system for speed control of coiler motor," IEEE Trans. Ind. Electron., Vol. IE-36, No. 1, pp. 8-17, 1989.

4. T. Ohmac, T. Matsuda, K. Kamiyama, and M. Tachikawa, " A microprocessor-controlled high-accuracy wide-range speed regulator for motor drives", IEEE Trans. Ind. Electron., Vol. IE-29, No. 3, pp. 207-211, 1982.

5. P. Katz, Ditigal Control Using Microprocessors, New York, Prentice-Hall International, 1981.

6. R.M. Goodall and D.S. Brown, " High speed digital controllers using an 8-bit microprocessor," Software and Micro-systems, Vol. 4, Nos. 5 & 6, pp. 109-116, 1985.

7. S.R. Bowes and M. J. Mount, "Microprocessor control of PWM inverters," Proc. Inst. Elec. Eng., Vol. 128, No. 6, pp. 293-305, 1981.

8. G. Buja and P. Fiorini, "Microcomputer control of PWM inverters," IEEE Trans. Ind. Electron., Vol. IE-29, No. 3, pp. 212-216, 1982.

9. E. Dwyer and B.T. Ooi, " A look -up table based microprocessor controller for a three phase PWM inverter," in Proc. IECI Ann. Mtg., Mar. 1979, pp. 19-22.

10. F. Harashima, S. Kondo, K. Ohnishi, M. Kajita, and M. Susono, "Multimicroprocessor-based control system for quick response induction motor drive," in Proc. IEEE-IAS 1984 Annual Meeting, pp. 605-611.

11. K. Kubo, M. Watanabe, T. ohmae, and K. Kamiyama, " A fully digitalized speed regulator using multiprocessor system for induction motor drives." IEEE Trans. Ind. Appl., Vol. IA-21, No. 4, pp. 100-108, July / Aug. 1985.

12. S. Sathiakumar, S. K. Biswas, and J. Vithayathil, " Microprocessor based field-oriented control of a CSI-Fed induction motor drive" IEEE Trans. Ind. Electron., Vol. IE-33, No. 1, pp. 39-43, Feb. 1986.

13. K.S. Rajashekara and J. Vithayathil, " Microprocessor-based sinusoidal PWM inverter by DMA transfer," IEEE Trans. Ind. Electron., Vol. IE-29, No. 1, pp. 46-51, Feb. 1982.

14. R. Jocnsson, " Measurements of a new ac induction motor control system", in Proc. European Power Electron. Conf., Aachen, Germany, pp. 17-22, 1989.

15. H. Y. Zhong, H.P. Messinger, and M.H. Rashad, " A new microprocessor based direct torque control system for three-phase induction motor", IEEE Trans. Industry Applications, Vol. 27, pp. 294-298, Mar. / Apr. 1991.