CHAPTER - III

MICROPROCESSOR BASED BIDIRECTIONAL OPERATION OF THREE PHASE INDUCTION MOTOR WITH PROTECTION AGAINST SINGLE PHASING, OVER AND UNDER VOLTAGE.
3 - 1. **INTRODUCTION**:

In many industrial utilisations bidirectional operation of the three phase induction motor with protection becomes a necessity for which, mechanical contactors are commonly used.

In this investigation mechanical contactors have been replaced by microprocessor based SCR controlled static contactor with a facility to provide protection against, over and undervoltages and single phasing with character display to identify the nature of fault. The system so developed being practically free from maintenance and noisefree in operation, is mechanically robust and extremely fast in switching action. The essential feature of the development lies in the fact that the system automatically provides any desired time delay for each reversal and also the control of the speed depending on Software.

3-2. **SYSTEM HARDWARE**:

The same hardware senser (Shown in Fig. 2-2) described in
in Chapter 2. has been employed for the bi-directional operation of three phase induction motor with protection against single phasing, permissible over and under-voltage utilising the INCONIX - IMS 5808 microprocessor kit, based on INTEL 8085A CPU chip. In this study the signal necessary for the microprocessor, in order to obtain the desired results after executing the software, is generated across the particular element ($R_g$) of the sensor circuit. A schematic block diagram of the system hardware is shown in Fig. 3-1, whereas the sensor circuit with rectifier and filter is shown in Fig. 3-2.

Necessary signal from the sensor circuit is first converted into d.c. by using rectifier and filter circuit. It is then fed to the microcomputer input port through ADC for performing the desired function after executing the software.

The Table 3-1: represent voltages developed across $R_0$ in mV under different mode of supply.
Fig. 3-2: Sensor circuit.
Fig. 3-3: Equivalent sensor circuit.
3-2.1 EXPERIMENTAL RESULTS.

The following table represents voltage developed across $R_0$ in multi-volt under different situations (viz. single phasing, under and over voltage, reversed phasing, voltage unbalance etc.) using $r=120k$, $C=0.01 \mu F$, magnitude of three phase line voltages being $400\pm12.5\% \ (V_l=V_R = V_{ph}, \ V_B = V_y = V_Y$  
$V_p=V_B=V_{ph}$

$a = e^{j\pi/3} \quad \text{a complex operator}$

<table>
<thead>
<tr>
<th>TABLE - 3.1</th>
<th>Voltage across $R_0=500$ ohms with input voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode of supply</strong></td>
<td><strong>(400+12.5%) V</strong></td>
</tr>
<tr>
<td></td>
<td>Analog Voltage in mV</td>
</tr>
<tr>
<td><strong>R-Y-B</strong> (Normal phase)</td>
<td>92</td>
</tr>
<tr>
<td>Single phasing with:</td>
<td></td>
</tr>
<tr>
<td>R-phase open</td>
<td>249</td>
</tr>
<tr>
<td>Y-phase open</td>
<td>249</td>
</tr>
<tr>
<td>B-phase open</td>
<td>174</td>
</tr>
<tr>
<td>Reversed Phase (R-B-Y)</td>
<td>448</td>
</tr>
</tbody>
</table>
3-3. **SYSTEM SOFTWARE**:

The voltage \( V_q \) developed across \( R_0 \) in the sensor circuit is fed to the microprocessor instantaneously through the ADC (Having resolution 12 bits and conversion rate 7.5 samples/see) Converting the analog voltage to its digital form and stored in a particular RAM location. Digital values of signals corresponding to the R-Y-B mode of supply, (i.e. 28H and FG H single phasing condition (i.e. 6D hand 3BH) and R-B-Y mode of supply (i.e. C4H and 99H) are stored in six particular RAM locations. System software has been so developed that after making the system on the instantaneous signal is brought to the Accumulator through ADC and is compared with 00 H to display blank with dot in the address field if the received signal is also 00H. Otherwise, if the instantaneous signal is within the zone of R-Y-B (Forward running) sequential condition of supply, considering the permissible under and over voltage limits (92mv and 71mv), corresponding digital signal for this particular case being (28H and IF H), the microcomputer is allowed to output a square wave signal through a particular channel of the I/O port to trigger S.C.R. for forward rotation after a definite adjustable time delay and it is again allowed to accept signals from the sensor in order to know whether it is within the zone of R-Y-B-mode of operation. If it is within the safety zone, microcomputer is allowed to output the square wave signal again to keep the system...
in operation. If it is below the working zone, the task of the microcomputer will be to display blank with dot in the address field without supplying the trigger pulse and if the instantaneous signal crosses the upper limit (28H) the received signal is compared with the stored digital data corresponding to lower limit (3BH) of single phasing condition. If the instantaneous signal is greater than the latter the microcomputer compares the instantaneous signal with the upper limit (6DH) of the single phasing condition and if the instantaneous signal is found less than the upper limit of the single phase condition, the microcomputer calls a delay subroutine to display 'SP' (Representing single phasing) in the data field after discontinuing to output square wave to provide protection and continues to compare instantaneous signal from sensor circuit and repeats the cycle of operation.

If the instantaneous signal is within the working zone corresponding to the R-B-Y mode of operation, considering the under and over-voltage limits (348 mV and 448 mV corresponding digital signals 99H and C4H), the microprocessor after making a definite delay is allowed to output a trigger pulse through a separate channel of the output port in order to operate the motor in reversed direction initialising I/O ports as input ports, it starts to receive signals from the sensor to examine whether it is within the R-B-Y zone of operation. It continues the cyclic operation within the marked zone. But if the
instantaneous signal becomes smaller than the lower limiting value (99H), the task of the microprocessor will be to display SP (Represent Single phasing) in the data field or output a square wave through the first channel of the I/O port after a definite delay depending on the condition of the signal viz, single phasing or R-Y-B mode of operation respectively. But if the signal crosses the upper limit (C4H) of the digital value corresponding to the R-B-Y mode of operation, the task of the microcomputer will be to display blank with a dot continuously receiving instantaneous reference signal from the sensor continues the cycle of operation without providing any trigger pulse.

It is clear that the microprocessor will select two different channels of the I/O port to fetch trigger pulse under R-Y-B (Forward) and R-B-Y (Reversed) mode of operation provided the supply is free from single phasing and within the specified under and overvoltage conditions. The outputs from the I/O port of the microprocessor being amplified and isolated and brought to the gates of the SCR's (1,2,3,4) for forward operation and (5,6,7,8) for reversed operation of the motor as shown in fig. 3-4. This diagram shows the static contactor arrangement for bidirectional operation of a three phase induction motor. The flow chart of the system software is shown in fig. 3-5. The program listing has been presented in Appendix -3.
Fig. 3-4: Static contactor for bi-directional operation of three phase induction motor.

Thyristors [1, 2, 3, 4] for forward operation.

Thyristors [5, 6, 7, 8] for backward operation.
Fig. Zero Crossing detector
Amplified output for triggering
Fig. 3.5. Flow chart of the software.

Start

Store upper and lower limiting signals corresponding to R-KB single phase (SP) and R-K-V mode of operation in six consecutive locations.

Store mode data OOH/OHH corresponding to Forward or Reverse rotation in the next location.

In signal from the sensor and store it in Acc in the next location.

Compare Acc with 00

Is Result Zero?

Yes Display blank with dot.

No Compare mode data with OOH

Is Result Zero?

Yes Call trip to disconnect the system from supply and halt.

No I.S. < I.L.L. Y-B ?

Yes Call DISP R-K-B in the address field.

No Call input to rotate the system in R-K-B mode.

In signal from the sensor.

I.L.L. = 25

No Call DISP R-K-V in the address field.

Is Result Zero?

Yes Call display SP in the address field.

No I.S. < I.L.L. SP ?

Yes No

Call DISP R-K-V

Fig. 3.5. Flow chart of the software.
3-4. **CONCLUSIONS** :

The developed microprocessor based static contactor for bidirectional operation of three phase induction motor with single phasing, under and overvoltage protection developed has the following salient features:

1. It allows adjustable time delay as desired by users for each reversal of rotation.

2. It provides bi-directional operation with protection against single phasing, over and undervoltage for a set value replacing mechanical contactor.

3. A major part of the hardware has been replaced by software.

4. It gives on-line indication of single phasing condition of three phase supply instantaneously.

5. For a particular mode of operation (R-Y-B/R-B-Y), the working zone may safely be modified by a mere change in the software as per requirement of the user.

6. It gives maintenance free long life, noise free
and fast switching action since the system is static.

7. The system is very simple in construction and reliable in operation.

3-5. REFERENCES:

BOOKS: 1, 2, 4, 6, 11, 13, 16, 17, 18, 19, 24, 25-39.

JOURNALS: 14, 21, 25, 63, 64, 79, 80-90.