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A Simple Scheme for Measurement of Power Frequency Deviation

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Abstract: ***Measurement of power frequency deviation is important for the design of power system equipments such as stabilizers, frequency meters etc. This paper has suggested a monitoring scheme using a 90 ^{0} phase shifter. The use of phase shifter makes it easier to compare the two frequencies, the nominal and deviated frequency.The shifted and normal frequency signals are combined through EX-OR gate. If the power frequency differs from its nominal value, a difference in the pulse counts of two successive pulses occur which will be proportional to amount of deviated frequency. This method has advantage of providing high resolution. Also it is very simple and less expensive as compare to other methods. The scheme is implemented using 8085 microprocessor.***

Keywords: Zero Crossing Detector, Deviation, Phase shifter, Resolution

I. INTRODUCTION

A synchronous electric power system is required to operate at a constant frequency, but because of randomly varying power demands and disturbances, the system line frequency tends to deviate from its nominal value [1]. To maintain the line frequency within specified limits, various control schemes are employed, such as load frequency control, frequency sensitive relays and other. The line frequency and its deviation are very important parameter for measuring accurately and monitoring continuously in an electric power system, for analyzing irregularities in its operation and for improving its operating security [2]. Measurement of power system freq deviation is also required in designing the automatic load shedding systems as well as in monitoring the system frequency. The continuous monitoring of system freq is also required for automatic generation control. Therefore accurate and quick measurement of freq deviation is very important in an interconnected power system.

There are various methods for accurately measuring the frequency deviation have been reported in literature which are based on leakage effects in magnitudes in a fourier transform calculation, level crossing, up-down counter etc. [3]. Earlier the similar work was done using an electronic bridge [4]. But the use of 8085 microprocessor results in fast operation and high resolution. Since digital signals are very popular and have less noise therefore this method likely to find wide applications in power system.

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II. FREQUENCY DEVIATION MEASUREMENT SCHEME

A simple scheme is suggested which is shown by a block diagram of fig.1

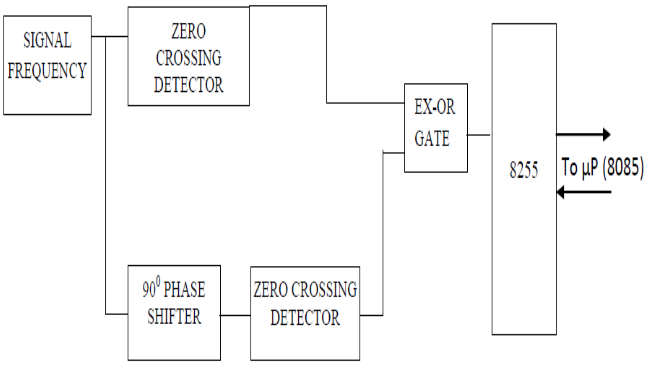

Fig 1: Block diagram for measurement of frequency deviation

A. Phase shifter

The circuit for phase shifter is shown in fig 2. When resistance $R_2 = R_3$ and are connected alone i.e. without R_1 and C_1, the circuit would behave as unity gain amplifier in inverting mode. However with additional R_1 and C_1 components, a phase difference of 90^0 can be introduced. By adjusting C_1 and R_1 the value of frequency can be adjusted.

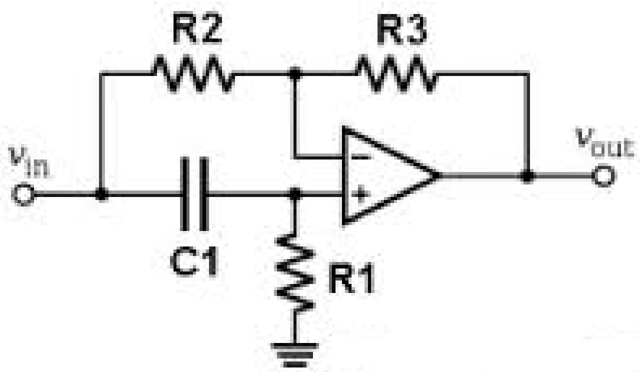

Fig 2: Phase Shifter

B. Zero crossing detector

It is a special case of comparator made from Opamp without feed back and a non-inverting terminal grounded. The slightest input voltage at the other terminal of the Opamp is enough to saturate it, because the input voltage needed to produce saturation are so small that the transition appears to be vertical. Thus ZCD converts the sinusoidal signal into a rectangular wave having only two binary levels, high and low, as shown in fig 3.

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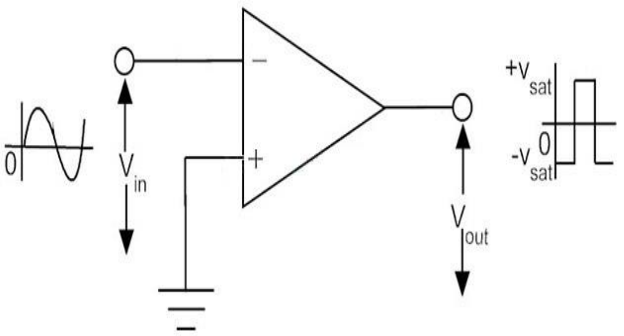

Fig 3: Zero Crossing Detector

III. EXPERIMENTAL WORK

The circuit is fabricated in lab. in which opamp as phase shifter and as zero crossing detector are used. The zero crossing detector converts the sinusoidal signal into a rectangular wave having two binary levels, high and low. The positive part of the sin wave is converted into low level and negative part into high level. The sinusoidal signal whose normal freq is known and whose deviation from the normal value is desired to be measured is transformed to a low voltage signal using a signal generator. This signal is then passed through a zero crossing detector to convert it into a train of pulses as shown by A in fig 4. These pulses are then applied to one of the inputs of EX-OR gate.

The sinusoidal signal is also applied to a phase shifting circuit made up from an OPAMP 741.

The phase shifting circuit introduces a phase shift of 90^0. The output of this phase shifter has a constant magnitude but its phase angle can be controlled. Since the desired signal frequency is known, the values of R and C can be adjusted to get $\varphi = \pi/2$ (i.e. $\omega RC = 1$). This 90^0 phase shifted signal is also passed through another zero crossing detector to convert it into another train of pulses as shown by B in fig 4. These pulses are then applied to another input of Ex-OR gate.

The output of Ex-OR is interfaced through Intel 8255 with an 8085 microprocessor for measurement and display. For 90^0 phase shift, two successive pulses of train C in fig 4 will be of equal width. However, when the phase shift is more than 90^0, the first pulse will have more width than the second successive pulse. Similarly if the phase shift is less than 90^0, second pulse will have more width. Thus the change in width of two successive pulses indicates the amount of phase shift which is proportional to the frequency deviation from its nominal value. It has been found that for small variation in frequency, the relationship between phase shift and frequency deviation is linear, as depicted in relation between frequency and pulse count in Table 1.

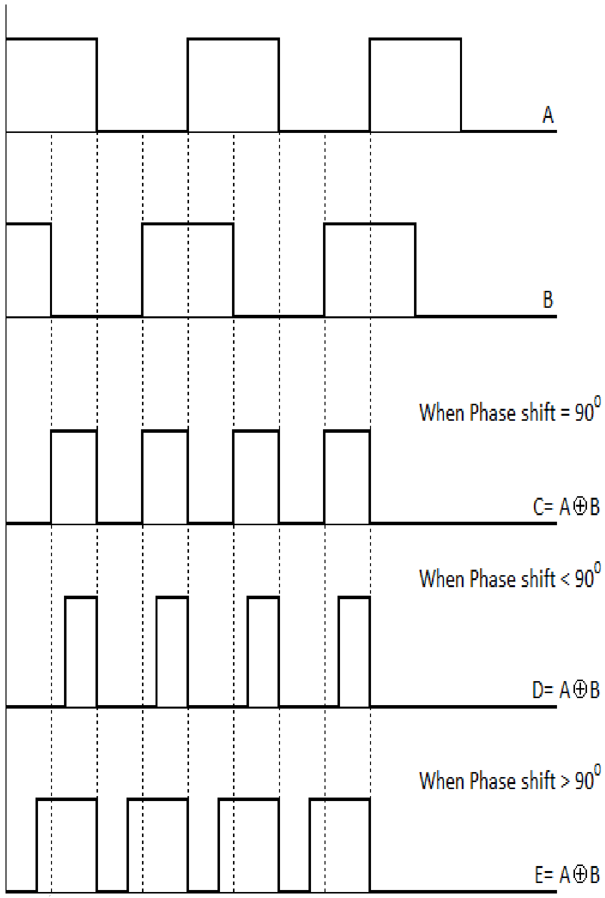

Fig 4: Signal Wave Forms

A. Wave forms description

The line frequency signal after passing through zero crossing detector is given in fig. A. The phase shifted wave form shows 90^0 phase shift as shown by B. When there is no deviation in frequency, the two successive pulses are of equal width. When the phase shift is more or less than 90^0, the pulses are of unequal width.

i) Frequency of 50Hz :
In this condition the phase shift is 90^0 as per signal wave form .The two successive pulses have same width that means deviation frequency is zero.

ii) Frequency less than 50 Hz:
In this condition the phase shift introduced is greater than 90^0 as can be seen from signal diagram. The width of positive pulse is more than negative pulse. If phase shift becomes 180^0 then there will be no pulse appear at signal D.

iii) Frequency Greater than 50 Hz:
In this condition phase shift is less than 90^0 as can be seen from diagram. The width of negative pulse is more than that of positive pulse.
Thus, change in width of two successive pulses indicates the amount of phase shift .It can also indicate the deviation in frequency from the nominal value. Hence as phase shift goes on decreasing and finally becomes zero degree then there will be no pulse on signal E

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B. Flow Chart

The program for measurement of frequency deviation is developed and run on 8085 microprocessor work station whose flow chart is given in Fig 5.

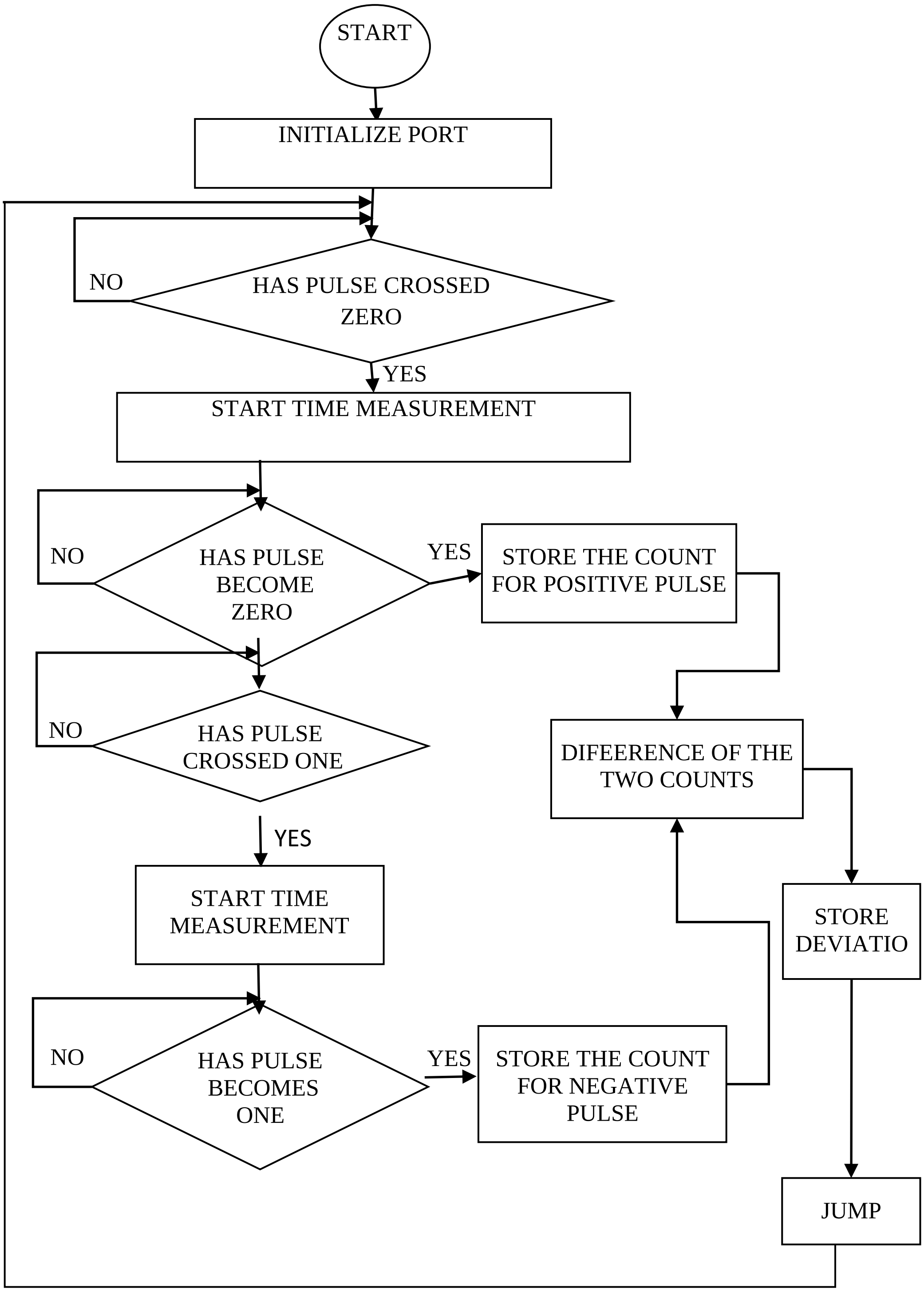

Fig 5: Flow Chart

IV. RESULTS

The result indicates good linearity between pulse count and frequency for frequency range of 45-55 Hz.

Table 1: Relationship between Frequency and Pulse count

S. No.	Frequency in Hz	Pulse count in KHz
1	47	3.1
2	48	2.0
3	49	1.0

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4	50	0.0
5	51	0.9
6	52	1.8
7	53	1.9

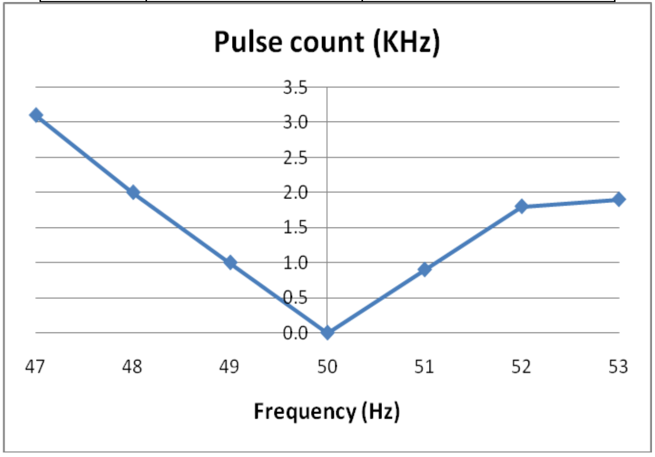

Fig 6: Graph showing relation between Frequency and Pulse count

For 50 Hz frequency signal the frequency deviation in terms of count D, is the time period difference which is calculated using the relation $\Delta f = D(\alpha+\beta D^2)$ where α and β are determined on the basis of microprocessor time for each count.

V. CONCLUSION

Fabrication of the circuit and interfacing aspects for measuring power frequency deviation from its nominal value has been discussed in this paper. The programming can be done with the help of flow chart given and experimental results are shown in table and graph. The beneficial feature of the proposed scheme include the use the single Ex-OR gate and a microprocessor for fast and accurate measurements. The same technique can be used for measurement of resistance and capacitance also. Test results show that the proposed scheme can provide easy and less expensive method with high resolution. The technique is suitable for use in microprocessor-based relays.

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