Microcontroller based phase meter

L. Shrimanth Sudheer, S.S. Patil*, R. Laxmikant, Nagabhushana Katte and P. Bhaskar

Department of Instrumentation Technology, Gulbarga University P.G. Centre, Yeragera - 584 133, Raichur, KA, INDIA

**Department of Electronics and Communication Engineering, S.L.N. College of Engineering, Raichur - 584 135, KA, INDIA*

Abstract : A microcontroller based phase meter has been designed and fabricated. The paper deals with the hardware and software features of the phase meter. The phase difference between the two signals is obtained by measuring the ON time 'τ' of the XOR gate and the time period 'T' of the signal using the two timers of C8051F020 microcontroller. The phase meter is designed for the measurement of phase difference between 0 - 360^{O} for frequencies up to 10 kHz with an accuracy of ± 0.1 at 500 Hz signal frequency.

Keywords : Microcontroller, C8051F020, Phase meter, Phase difference.

1. INTRODUCTION

The phase meter has innumerable applications in industry and R&D laboratories. Although several attempts have been made to design and fabricate both analog and digital phase meters, they suffer from limitations like compactness, complexity in design, lack of storage, and serial communication facilities etc., which are very important for research applications. The microcontroller C8051F020 [1] based phase meter overcomes the above difficulties.

2. PRINCIPLE

The principle involved in the design of the microcontroller based phase meter is similar to the principle involved in the conventional digital phase meter [2]. The measurement of the phase is based on the relationship of the phase angle to the delay between the zero crossings of two input signals. As shown in Fig.1, the phase shift 'ϕ' and the delay 'τ' between the zero crossings of the signals is presented by a simple equation below;

$$\phi = (\tau / T) * 360 \quad \ldots\ldots\ldots\ldots \quad (1)$$

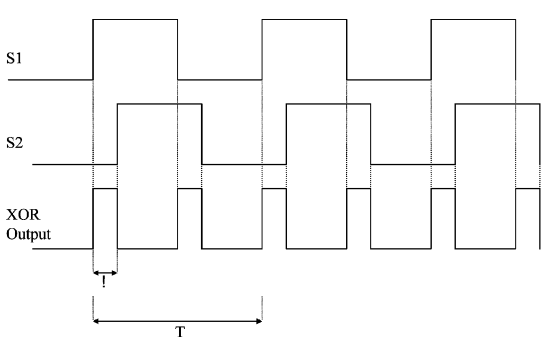

Fig. 1. Input and output waveforms of XOR gate

where 'T' is the time period of the signal and 'ϕ' is the phase difference in degrees.

3. WORKING OF MICROCONTROLLER BASED PHASE METER:

Fig. 2 shows the schematic diagram of a C8051F020 microcontroller based phase meter. Flip-flops 1 and 2 convert the two input signals S1 and S2, into square wave signals of a 50% duty cycle. The frequencies of these square waves is half that of the input signals. If the signals are directly applied to the XOR gate, only a phase difference of 180^{O} can be measured. The outputs of these two flip-flops are applied to an XOR gate which produces a signal that's 'ON' time 'τ' is proportional to the phase difference between these two signals. The 'ON' time of the XOR gate varies linearly with the phase difference from 0 - 360^{O}. Fig.3 shows the linear relationship between the phase angle and the output of the XOR gate [5].

The output of the XOR gate and that of flip-flop-2 are applied to the interrupt inputs INT0 and INT1

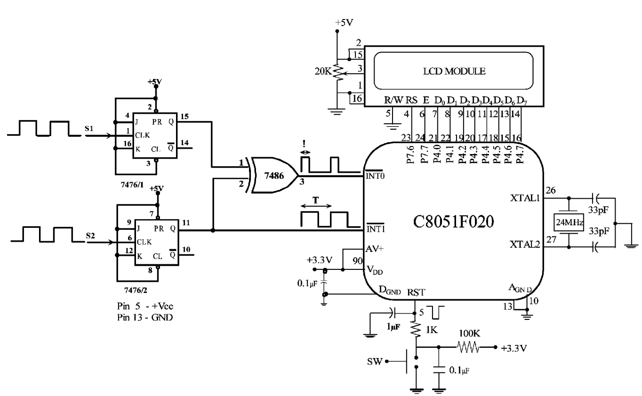

Fig. 2. Circuit diagram of microcontroller based phase meter

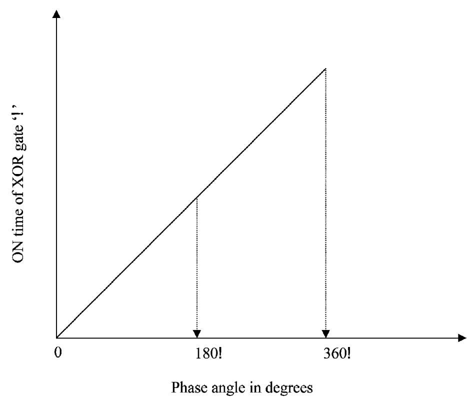

Fig. 3. Phase angle versus on time of output of XOR gate

respectively. Here Timer-0 and Timer-1 are used to measure the 'ON' times ('τ' and 'T') of the signals applied at the INT0 and INT1 of microcontroller. Timer-0 and Timer-1 are programmed in mode-1 and the GATE bits in the TMOD register are set. This makes the internal 24MHz clock available to Timer-0 and Timer-1 for counting only when INT0 & INT1 pins are HIGH and TR0/TR1 in the TCON register are set. The interrupts are programmed to occur on a HIGH-to-LOW transition on INT0 & INT1 pins. Initially Timer-0 & Timer-1 are cleared and TR0/TR1 bits are set. The Timer-0/ Timer-1 begins counting when the input pulse goes HIGH, and stops when the pulse goes from HIGH-to-LOW. This HIGH-to-LOW transition of the pulse also generates an interrupt signal to the microcontroller. The program control is transferred to the interrupt service routine and reads the contents of Tmer-0/Tmer-1. When the interrupts are generated, the Timers' content is read and substituted in equation (1) to get the phase angle between the two signals in degrees. The phase is then displayed on the LCD module.

4. SOFTWARE

The software first initializes the stack pointer and the LCD module. After initialization of the LCD module, the program then initializes Timer-0 in mode-1 and a GATE bit in the TMOD register is set. Timer-0 is loaded with 0000H, and then the software sets a TR0 bit in the TCON register. When the INT0 input goes HIGH then Timer-0 starts counting the internal clock (24MHz). The program then enables a timer-0 interrupt by setting ET0 and EA in the interrupt enable register. The external pulse HIGH-to-LOW transition stops timer-0 and generates an interrupt signal which interrupts the CPU. Program control is then transferred to location 0003H and from there is again transferred to location 'tow_isr'. There, it

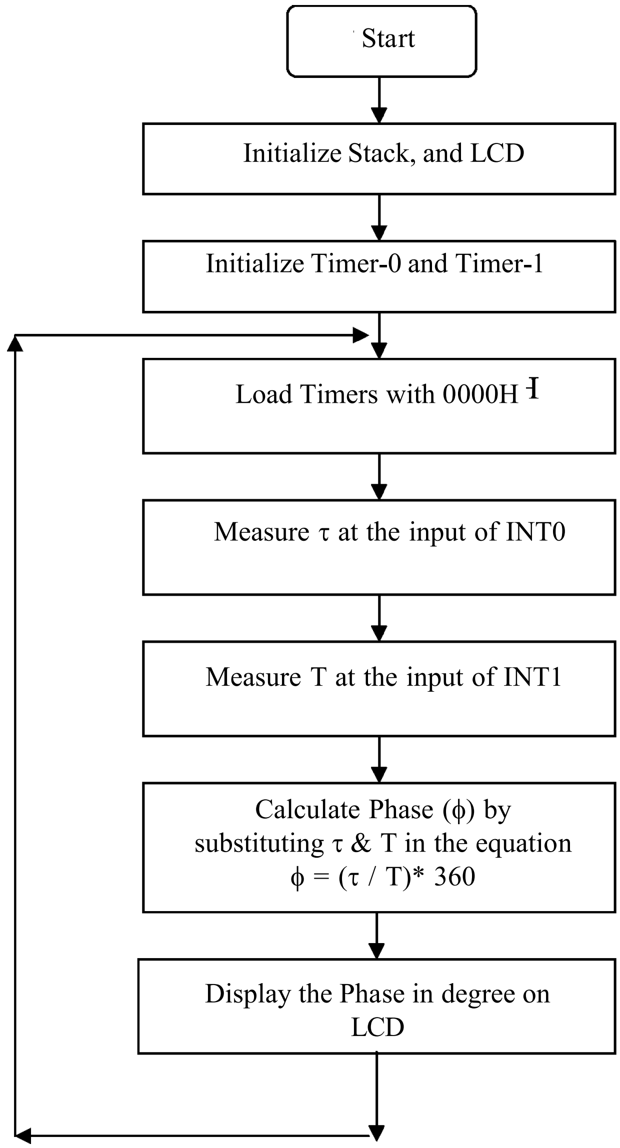

Fig. 4. Flowchart of phase angle measurement program

disables interrupts and reads the contents of Timer-0. Then the count is assigned to a variable 'tow'. The same procedure is repeated for the measurement of 'T' using Timer-1 and INT1 input. Finally, the program calculates the phase angle by substituting the 'τ' and 'T' in equation (1). For continuous measurement, the program reinitializes Timer-0/Timer-1, enables interrupts and then returns to the main program.

5. RESULTS

The microcontroller based phase meter has been designed and fabricated by the authors. The output of the phase meter is tabulated in Table-1. The phase meter is designed for the measurement of the phase difference from 0 to 360^{o} for frequencies up to 10 kHz with an accuracy of ± 0.1 . The system can be made simple and

S. No.	Phase Angle Φ in degrees measured on CRO	Phase Angle Φ in degrees measured with the meter for Frequency = 500 Hz
1	0	0
2	45	45.2
3	90	90.2
4	135	134.8
5	160	160.1
6	180	180.4
7	210	209.8
8	225	225.2
9	270	269.6
10	315	315.0

Table 1 : The observations of phase meter

low cost by employing AT89C2051 microcontroller for the frequency range from 0 to 1 kHz, but the accuracy decreases for higher frequencies.

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