Simple Design Of Analogue Signals Frequency Meter

Othman Mohammed[*]
Higher institute of science and technology, Cyrene, Libya

Tahani Abdalmawla
Department of computer science, faculty of science, University of Omar Al-mukhtar, El-beida, Libya.

Aboubakr Adim
Higher institute of science and technology, El-beida, Libya.

[*]*Corresponding Email:* ***othmanlby@gmail.com***

SJST

Othman, Tahani and Aboubakr / SILPHIUM Journal of Science and Technology. 7(1), 2025, 83-93.

SILPHIUM JOURNAL OF SCIENCE AND TECHNOLOGY
(SJST)

Simple Design Of Analogue Signals Frequency Meter

Othman Mohammed[1*], Tahani Abdalmawla [2], Aboubakr Adim[3]

[1] *Higher institute of science and technology, Cyrene, Libya.*

[2] *Department of computer science, faculty of science, University of Omar Al-mukhtar, El-beida, Libya.*

[3] *Higher institute of science and technology, El-beida, Libya.*

*Corresponding Email: **othmanlby@gmail.com***

Received 27/08/2024 Revised 14/11/2024 Published online 24/01/2025

ABSTRACT

During the first decade of the twenty-first century, significant advancements were made in machine measurement engineering, design, and control. Signal processing and the study of its characteristics serve as fundamental pillars in numerous scientific disciplines, particularly in applied sciences such as engineering, science, computer science, and space science etc. Frequency is a crucial factor influencing the characteristics and shape of signals. Frequency plays a crucial role in determining the characteristics and shape of signals, making its measurement essential in numerous industrial and research contexts.

This paper aims to design and simulate a frequency measurement system for analogue signals. The frequency measurement range extends from 1Hz to 65khz, with an error rate of approximately 0.1% for frequencies exceeding 60KHz Based on developed board IDE, of the PIC16F84 microcontroller, the control function and frequency calculation of the input signal are designed and implemented. The analogue signal to be measured is converted into a pulsed signal with the same frequency across two circuits, respectively. The first filter circuit isolates and removes all DC components of the signal, while the second circuit is a zero-crossing circuit (ZCD) for generating a pulsed signal with the same frequency as the original signal. The output of the second circuit serves as an input to the microcontroller. The C programming language is utilized for the development panel of the controller. Results are displayed on an LCD screen connected to the control panel, demonstrating the system's efficacy in accurately measuring frequency. The findings indicate that the proposed frequency measurement system is reliable and effective for a wide range of applications in both industrial and scientific research.

Keywords: PIC16F84 microcontroller, Frequency, LCD, C programming language, IDE.

تصميم مبسط لجهاز قياس تردد الإشارات التماثلية

عثمان عبدالله محمد*[1]، تهانى عمر عبدالمولى[2]، أبوبكر صالح ادم[3]

[1]المعهد العالي للعلوم والتقنية، شحات، ليبيا

[2]قسم الحاسوب، كلية العلوم، جامعة عمر المختار، البيضاء، ليبيا.

[3]المعهد العالي للعلوم والتقنية، البيضاء، ليبيا

*للمراسلة: Othmanlby@gmail.com

الملخص:

خلال العقد الاول من القرن الواحد والعشرين شهد علم هندسة القياس بالآلات والتصميم والتحكم تطورا كبيرا وهام جدا. يعتبر مجال معالجة الإشارة ودراسة خصائصها ركيزة أساسية في كثير من العلوم، وبشكل أساسي في العلوم التطبيقية مثل العلوم الهندسية وعلم الحاسب الآلي وعلوم الفضاء الخ. أحد العوامل الهامة التي تؤثر في خصائص وشكل الإشارة هو التردد. ويعتبر قياس التردد للإشارات اساسي ومهم في كثير من مجالات الصناعة والبحث العلمي. الهدف من هذه الورقة هو عمل تصميم ومحاكاة لنظام قياس الترددات للإشارات التماثلية. يكون نطاق قياس التردد من1هيرتز الى 65 كيلو هيرتز بنسبة خطأ 0.1 % للترددات الأعلى من 60 كيلوهرتز. بالاعتماد على اللوحة المطورة للمتحكم الدقيق تم تصميم وإنجاز دوال للتحكم وحساب تردد الإشارة الداخلة للمتحكم. يتم تحويل الإشارة التماثلية المراد قياس ترددها الى إشارة رقمية بنفس التردد عبر دائرتين على التوالي. الأولى دائرة مرشح لعزل وحذف جميع المركبات المستمرة للإشارة، ثم الدائرة الثانية هي الدائرة المتقاطعة الصفرية للحصول على إشارة رقمية بنفس التردد للإشارة الام. يكون مخرج الدائرة الثانية كمدخل للمتحكم. تم تطبيق لغة البرمجة C للوحة المطورة للمتحكم. وتعرض النتائج خلال شاشة عرض الكريستال السائل المتصلة باللوحة. تم عرض النتائج لإثبات نجاح النظام المقترح.

الكلمات المفتاحية: المتحكم الدقيق، قياس التردد، لغة البرمجة C، شاشة عرض الكريستال السائل. اللوحة المطورة.

INTRODUCTION

The Conventional frequency meters can be constructed using standard hardware circuit combinations. However, this approach involves an extended development period and a complex debugging process. Furthermore, due to the interference among electronic components, which adversely affects accuracy, and the disadvantage of substantial size, traditional frequency meters no longer meet contemporary requirements. In contemporary practice, frequency meters are typically constructed utilizing Field-Programmable Gate Arrays (FPGAs), microcontrollers, and a series of integrated circuits (ICs) (Zheng, 2022). In the present days, numerous methods exist for measuring the frequency. Ordinarily used methods encompass interpolation and cursor method (Zhi-Wen et al., 2012), precision frequency measurement method, frequency difference multiplication method (Yang, 2012), phase comparison method (Du et al., 2018) , direct frequency measurement method and period measurement method(Su et al. 2017). Nevertheless, the initial approaches have certain limitations. The interpolation and cursor techniques, designed for analogue circuits, introduce complexity and instability to circuit design. The frequency difference approach, primarily utilized for assessing frequency stability, exhibits poor resistance to interference. While the equal precision frequency measurement method offers high accuracy and swift operation, it predominantly relies on programmable logic devices (PLD), necessitating more intricate programming. Frequency accuracy and stability measurements typically rely on the phase comparison technique, with the precision of these measurements being limited by the constraints of the hardware equipment.

The objective of this paper is to develop a device for measuring sinusoidal signal frequencies using the direct frequency measurement technique, specifically implemented on the PIC16F84A microcontroller. This microcontroller is recognized for its robust capabilities and ease of customization, making it an ideal choice for this application. The direct frequency measurement approach is employed to enhance the accuracy and efficiency of frequency detection. The signals are typically processed through advanced filtering techniques and zero-

crossing circuitry to certify that the signal amplitude conforms to the TTL input specifications of the microcontroller.

System Architecture

Sinusoidal signals are normally passed through a filter and a zero-crossing circuitry to formulate the signal amplitude compatible with TTL input of microcontrollers. The frequency and period of the resultant pulse train are then measured by the microcontroller. The internal timer of the crystal-based microcontrollers provides reasonably accurate results. The display normally consists of LCD device interfaced to one of the ports on the microcontroller.

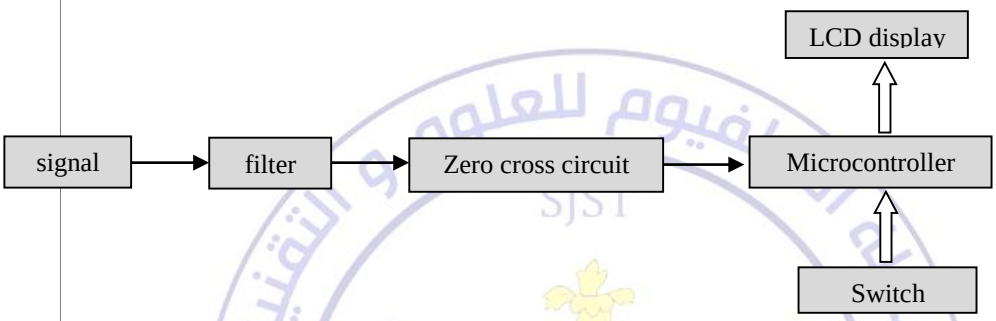


Figure 1. block diagram a frequency meter

1. Microcontroller

According to data sheet (Microchip Technology Inc. 1996-2013, n.d.), The PIC16F8X is a group in the PIC16CXX family of low-cost, high performance, CMOS, fully-static, 8-bit microcontrollers. It utilizes an advanced RISC architecture. PIC16F84 devices possess enhanced core features, an eight-level deep stack, and multiple internal and external interrupt sources. The separate instruction and data buses of the Harvard architecture facilitate a 14-bit wide instruction word with a distinct 8-bit wide data bus. Furthermore, a substantial register set is employed to achieve a high level of performance. In addition, it incorporates up to 68 bytes of RAM, 64 bytes of Data EEPROM memory, and it contains input and output Ports which involve 13 I/O pins. A timer/counter is also integrated. In Figure (2), A PIC16F84 Microcontroller is shown.

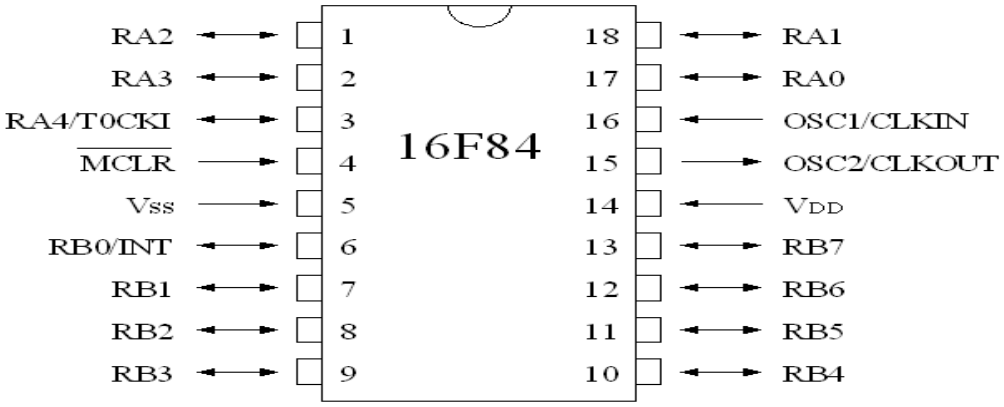


Figure 2. PIC16F84 Microcontroller *(Microchip Technology Inc. 1996-2013, n.d.)*.

2. Filter Circuit

A Passive RC filters attenuate undesired signals by selectively allowing the passage of sinusoidal input signals based on their frequency, with the most basic configuration being a passive low-pass filter network. In low-frequency applications (up to 100kHz), passive filters are typically constructed using simple RC (Resistor-Capacitor) networks. These filters lack amplifying elements and consequently do not provide signal gain; therefore, their output level is invariably lower than the input (‘Passive Low Pass Filter’, n.d.).

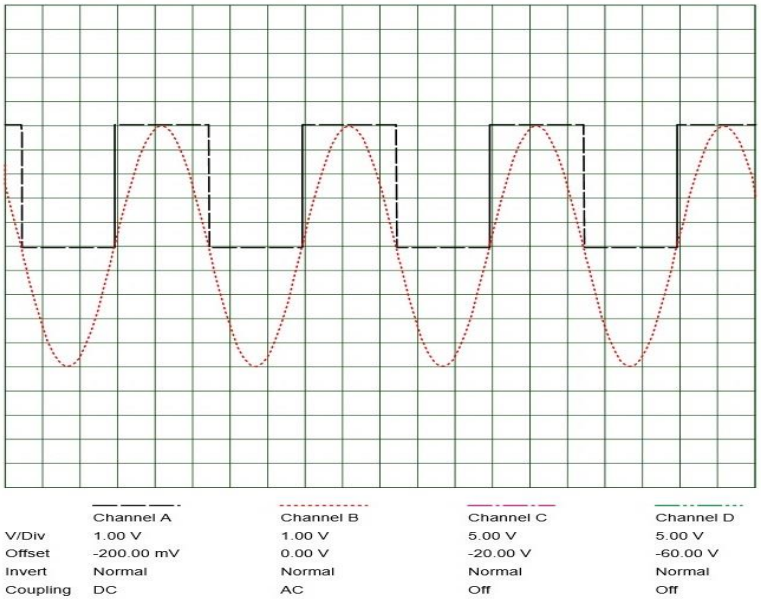


Figure 3. Input/Output signal of ZCD

3. Zero Cross Circuit Detector (ZCD)

The zero cross circuit detector (ZCD) involves integrated circuit LM358 and transistor 2N2222 (‘Zero Crossing Detection Circuits Examples, Applications and simulations’, n.d.). The circuit generates an output signal equivalent to the incoming analogue signal, maintaining the same frequency with logical values (1-0) (Irmak et al. 2011). The circuit output is connected to the RA4 pin of the PIC16F84 microcontroller. Figure (3) shows the Sinusoidal input and pulse output signal of ZCD.

4. Liquid Crystal Display (LCD)

LCD is an electronic presentation module which produces a visible image by utilizing liquid crystal. It displays characters, numbers and special characters. Resolution 16x2 character display (16-character columns and 2-character rows). Character size Approximately 5x7 dot matrix. Operating voltage 5V. (Supports common TTL levels) (Mark Palmer, n.d.).

5. Push Button Switch

The push button switch is a kind of switch that comprises of a basic electrical technique or an air switch technique to turn on or off (Farnell, n.d.).

6. Software Design

The Proteus Design Suite is an Electronic Design Automation (EDA) software utilized primarily by electronic design engineers for designing schematics and electronic prints for manufacturing printed circuit boards (Arif et al., 2024). In this proposed system, the software is employed for schematic design, and microcontroller simulation.

The system was simulated on the PIC16F84 development board. The program is written in C language in IAR Workbench IDE. The IAR Workbench IDE (integrated development environment) is a professional IDE for PIC, including a C/C++ compiler, the code analysis tools C-STAT and C-RUN, and the C-SPY debugger (Mohammed et al. 2021).

DESIGN METHODOLOGY

The direct frequency measurement means that the number of alterations in unit time. thus, the F_x. In order to measure F_x , the "t" is set to the reference.

Generally, "t" is assumed T_c. The pulses number of the signal is counted in the T_c time, which the number is N_x.

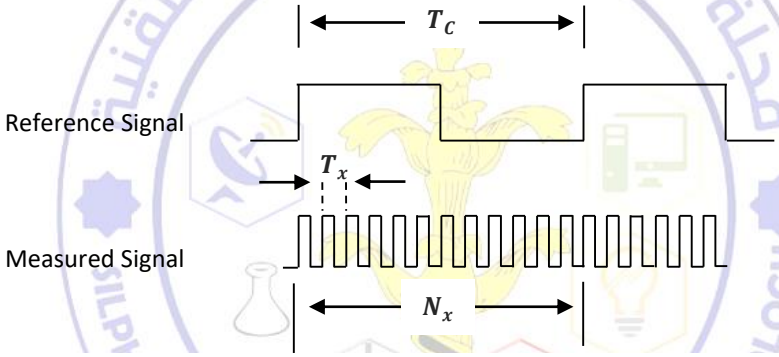


Figure 4a. Direct Frequency Measurement Method *(Su et al., 2017)*.

If the counter starts counting, the measured signal is generating N_x pulses in T_C Time. The frequency of the measured signal would be:

$$T_X = \frac{T_C}{N_X}$$

$$F_x = N_x * F_C$$

In the system, T_C is set to 1 second to make the count equals the measured frequency.

By using the timer flow interrupt, the microcontroller can calculate the interrupt number in the delay time. The formula is shown as following:

Frequency = 256× timer_flow_interrupt + TMR0

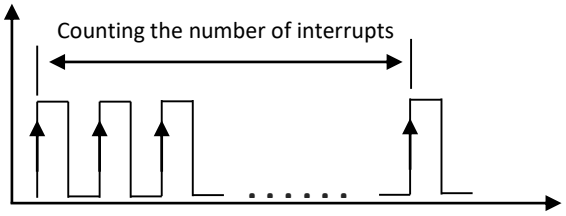


Figure 4b. Direct Frequency Measurement Method*(Su et al., 2017)*

The output of a ZCD is connected to PORTA pin 4 of PIC16F84 microcontroller, which the reason is the only one timer/counter that is RA4. This method of frequency measurement depends on the counter mode of TMR0, thereby achieving count of interrupt number. The PIC16F84 has one 8-bit prescaled timer/counter. In counter mode, the TMR0 is incremented either on rising or on falling edge of pin RA4/T0CKL. I configured the counter mode, thereby count the number of interrupts in the delay time.

Table 1.Registers Values

Register	Value
OPTION	0x20
INTCON	0xa0

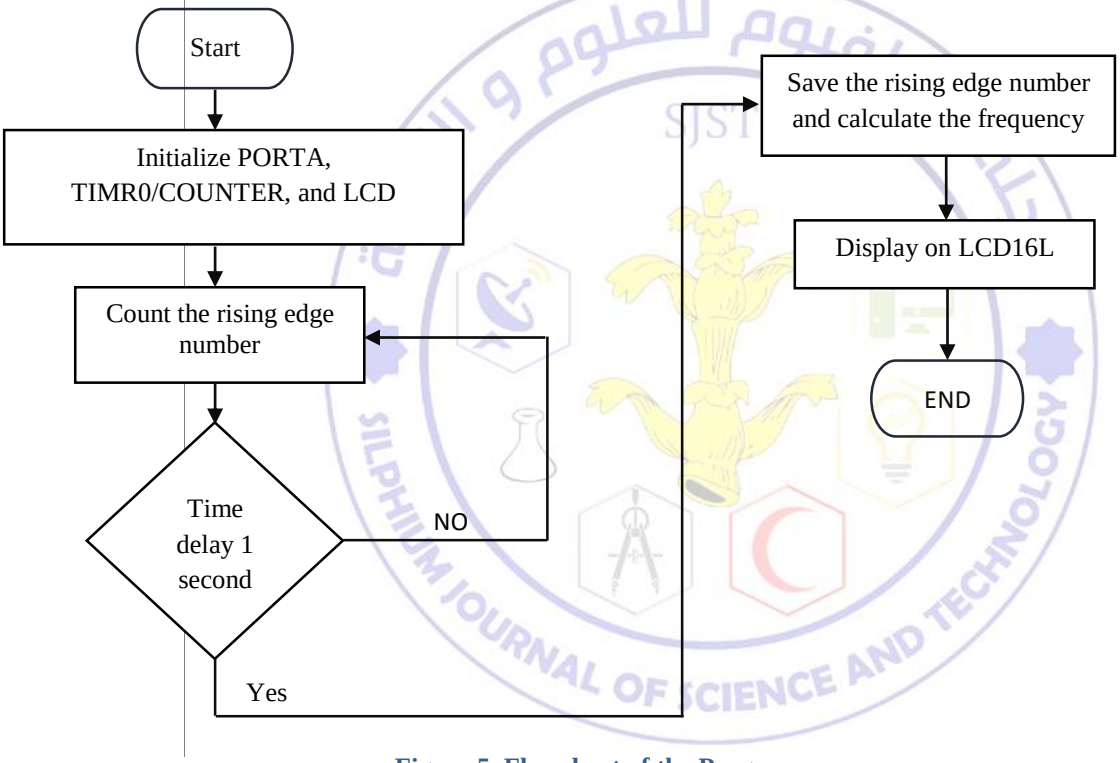


Figure 5. Flowchart of the Program

Results

LCD displays the frequency value that is measured through calculation of the function. Data of the experiment are presented in the following table:

Table 2. Data of experiment

The input Analogue signal frequency [Hz]	Measured frequency [Hz]
1	1
10	10
100	100
1000	1000
10000	10002
20000	20007

30000	30017
40000	40030
50000	50046
60000	60066
65000	65078
66000	460

Discussions

The findings presented in Table 2 indicate that at low frequencies, specifically within the range of 1 Hz to 10 kHz, the recorded values remain consistent. However, it is observed that the errors associated with frequency measurement tend to increase as the frequency of the incoming signal rises. Notably, when the frequency surpasses 65 kHz, the frequency meter displays inaccurate values. This discrepancy can be attributed to insufficient delay time during the measurement process. While the underlying principles of frequency measurement are reasonable, the inherent uncertainty in the interrupt response time of the microcontroller introduces potential for error.

The microcontroller tasked with executing multiple interrupt commands, which leads to impulse errors and further compromise the accuracy of the frequency readings (Wei.C et al. 2006). Thus, improvements in delay time and interrupt handling are necessary to enhance measurement precision at higher frequencies.

Conclusion

The paper has been successfully presented an effective measurement system. In This system the analogue signal is converted to a pulse signal and connected to the microcontroller via two electronic circuits. Frequency meter has been tested from 1 Hz to 65kHz by using an approach of counting interrupt number. The system is designed using Programmable Integrated Circuit PIC16F84 microcontroller. The results demonstrated that the system performs well enough to meet the anticipated requirements.

References

1. *Arif, A. R. S., Akhmad Nuriyanis, Ario Hendartono, Evi Sirait, Fajar Sari Kurniawan, & Candra Oktyasari Putri. (2024). Analysis of the use of Proteus Software as a Practical Learning Support. INTERNATIONAL JOURNAL ENGINEERING AND APPLIED TECHNOLOGY (IJEAT), 7(1), 30–39. Retrieved from https://doi.org/10.52005/ijeat.v7i1.96*

2. Du, B., Li, S., Huang, G., Geng, X., Li, Z., Deng, R., & Mo, C. (2018). High-precision frequency measurement system based on different frequency quantization phase comparison. *Measurement*, 122, 220–223. Retrieved from https://doi.org/https://doi.org/10.1016/j.measurement.2018.02.063

3. Farnell. (n.d.). Pushbutton Switches Datasheet. Retrieved 12 December 2024, from www.newark.com

4. Irmak, E., Colak, I., Kaplan, O., & Guler, N. (2011). Design and application of a novel zero-crossing detector circuit. In *International Conference on Power Engineering, Energy and Electrical Drives*. Retrieved from https://doi.org/10.1109/PowerEng.2011.6036535

5. Mark Palmer. (n.d.). *Interfacing PICmicro® MCUs to an LCD Module*. Retrieved 10 December 2024 from Microchip.com

6. Microchip Technology Inc. 1996-2013. (n.d.). Data Sheet PIC16F8X. Retrieved 7 December 2024 from Microchip.com

7. Mohammed, S., Mohamed, M., & Abdalmawla, T. (2021). Design and Simulation of Engine Management System. In *ACM International Conference Proceeding Series*. Association for Computing Machinery. Retrieved from https://doi.org/10.1145/3492547.3492605

8. Passive Low Pass Filter. (n.d.). Retrieved 12 December 2024, from https://www.electronics-tutorials.ws/

9. Su, L., Shang, A., Qin, J., & Yang, J. (2017). *Design and Implementation of High Precision Digital Frequency Meter Based on C8051F020 Microcontroller*.

10. Wei.C, ShuQing, & W, Hui. W. (2006). The research of frequency measurement base on the microcontroller. *Journal of Wuhan University of Science and Engineering*.

11. Yang, L. (2012). Modeling and analysis of frequency standard equipment based on frequency difference multiplication method. *Modern Electronics Technique*. Retrieved from https://consensus.app/papers/modeling-and-analysis-of-frequency-standard-equipment-yang/8006953483d95434b912095cd461c8ee/

12. Zero Crossing Detection Circuits Examples, Applications and simulations. (n.d.). Retrieved 7 December 2024, from https://microcontrollerslab.com/zero-crossing-detection-circuits-examples-applications/

13. Zheng, Y. (2022). Simple design of digital frequency meter based on microcomputer (p. 91). SPIE-Intl Soc Optical Eng. Retrieved from https://doi.org/10.1117/12.2627912

14. Zhi-Wen, Z., Yuan, T., & Jian, L. (2012). High Precision Frequency Measurement System Design. *Journal of Xi'an Technological University*, 32, 507–511. Retrieved from https://consensus.app/papers/high-precision-frequency-measurement-system-design-zhi-wen-yuan/587924bd1097551aa6b725d40518ced0/