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Contents

Design and Construction of Virtual Oscilloscope Using PIC Microcontroller

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Abstract

The virtual oscilloscope is handy little test gear and of benefit to any electronic workshop. In this system, an alphanumeric liquid crystal display (LCD) and PIC 16F877 microcontroller are used to display the signal waveform as well as the frequency and the peak-to-peak voltage of the input signal.

Introduction

Oscilloscopes are very useful in electronic measurements such as the frequency and voltage of any input signals. It can also display the waveform of the signal. In addition, the oscilloscope is very useful in fault-diagnosis and repairing electronic equipment. However, the oscilloscopes are very expensive to buy individually. The Virtual Oscilloscope presenter here is not only cheap also a handy little test gear and benefit to anyone's workshop.

The little unit is designed based upon the PIC Microcontroller. Using PIC, the circuit is simple and efficient compared to normal digital circuits because of its own EEPROM memory. This unit can be used:

- To measure frequency and peak-to-peak voltage of any signal including dc;
- To display the waveform of the input signal

The alphanumeric Liquid Crystal Display (LCD) is used to display the measurement results. It can display the measured frequency, peak-to-peak voltage, and waveform of the input signal. The frequency range covered is audio frequency but the range can be increased by modifying the program.

General Overview of PIC16F87X Family

Arizona Microchip, the manufacture of the PIC devices, have introduced a new range to the family, the PIC16F87x series. In many respects, these new devices can be regarded as greatly enhanced versions of the PIC16F84 (more specifically, they are CMOS Flash versions of the existing PIC16C73/74/76/77 devices). Importantly they have greater memory capacity than PIC16F84 could not readily provide complete control solutions. Of particular important are their several on-chip analog-to-digital converters (ADCs), and their communication options based upon internal USART (Universal Synchronous Asynchronous Receiver Transmitter) protocols. Pinouts on the standard plastic dual-in-line (DPIP) packages are given in Fig (1).

LCD Display

Alphanumeric dot matrix liquid crystal display (LCDs) are used for displaying visual information, symbols, alpha numeric and icons in an impressive fashion. These modules have built-in controllers, drivers, character generator RAM/ROM, and associated circuitry for easy implementation of the logic for refreshing, multiplexing and updating the display, LCDs are usually controlled by microcontrollers. LCDs come in many shapes and sizes but the most common is the 16 character × 2 line display, LCD modules is an LCD dot matrix display module that consists of an LCD panel and controller/driver circuits. It is capable of displaying two lines of 16 characters. This module provides both 8 bit and 4 bit parallel interfaces, and allows the controlling microprocessors to read and write data directly. Fig (2) shows the 2×16 LCD display.

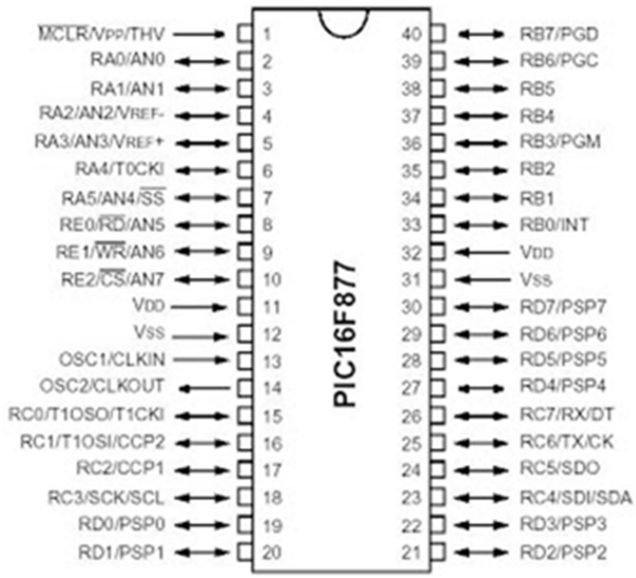

Figure 1. Pinout details for the PIC16F877 microcontroller

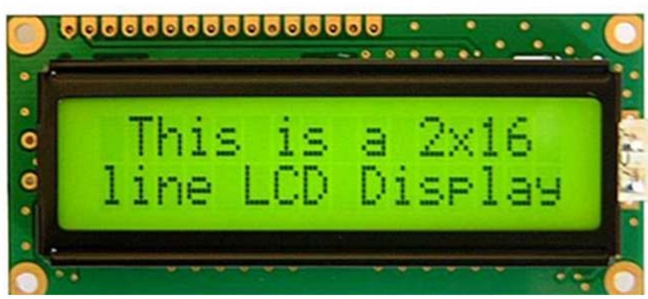

Figure 2. (2×16) LCD Display

Power Supply Unit

Almost all electronic circuits required a dc source of power. Electronic equipments are energized by a power supply, a piece of equipment which converts the alternating voltage from the power lines into an essentially direct voltage. An unregulated power supply consists of a transformer, a rectifier and a filter. The transformer is use to step up or step down the input ac voltage.

Circuit Details

Block diagram of the operational circuit and complete circuit diagram is shown in Figure 3 and Figure 4 respectively. 5V regulator is used to supply the whole circuit. The complete circuit diagram of the power supply is shown in Figure 5. The transformer T1 step-down the input ac main voltage into 12V ac. Rectifier and filter capacitor rectified the 12V ac into ripple-free dc voltage. IC3 (7805), 5V voltage regulator converts into stabilized 5V dc to supply the whole circuit. The signal to be measured is brought into op amp IC1a. As set by resistors R1 to R3. The gain can be selected by switch S1 to be ×1(unity – via R2) or × 10 (via R1). Other gain setting values could be chosen instead. Switch S2 provides selection of ac or dc signal coupling, switching capacitor C1 in and out of circuit. The output from IC1 to the microcontroller is dc coupled. Dual op-amp C4558 is used for IC1, with the second half ignored.

Microcontroller PIC16F877

Microcontroller IC2 is a PIC16F877 device, operated at a clock rate of 4MHz, as set by crystal X1. Because of this clock rate, 20MHz version of the PIC is used. PORTA is used for analog-to-digital conversion via from five of its pins (RA0 to RA3, plus RA5). In this design, only RA0 (pin 2) is used, its input being taken directly from the output of op-amp IC1a at pin1. Internally, the PIC is programmed by the software so that the voltage reference for the ADC is taken as 0V to 5V. Consequently, an A to D conversion value of 255 results when the input to RA0 is at 5V. A result of zero occurs when the RA0 input is a 0V. Output to the LCD is via PORTB, using lines RB0 to RB5 to control the display in conventional 4-bit mode.

External Control

External control of the PIC's monitoring and timing functions is actioned via PORTC, through pins RC0 to RC2. The controlled functions are the ADC sampling rate (via S3), waveform synchronization 0n/off (S4), and frequency counter display on/off (S5).

Construction

Details of the pcb component and track layouts are shown in Figure 6.

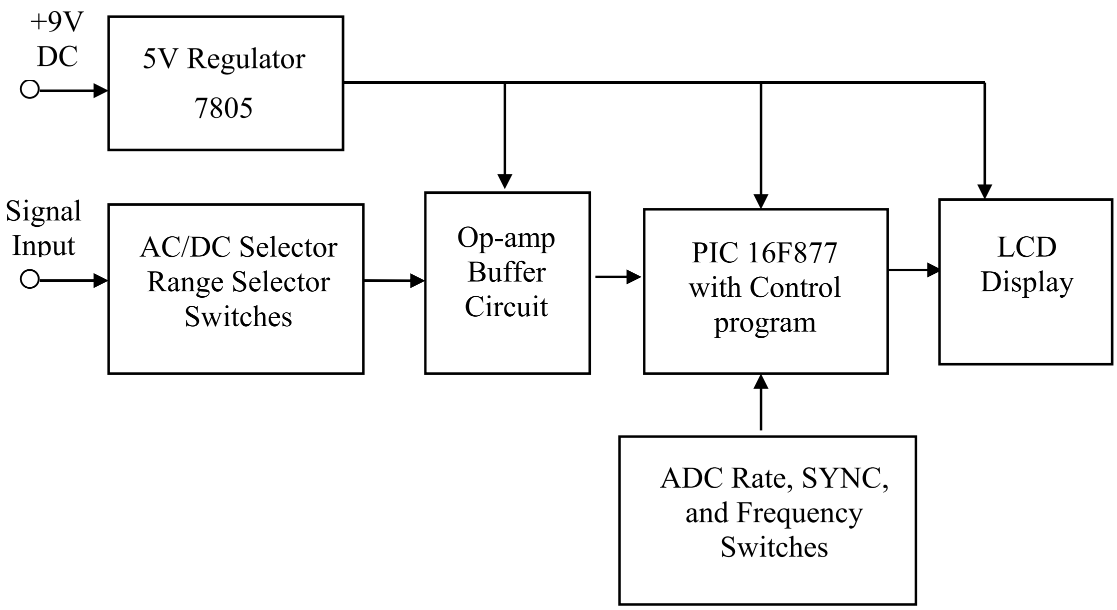

Figure 3. Block diagram of the "Virtual Oscilloscope"

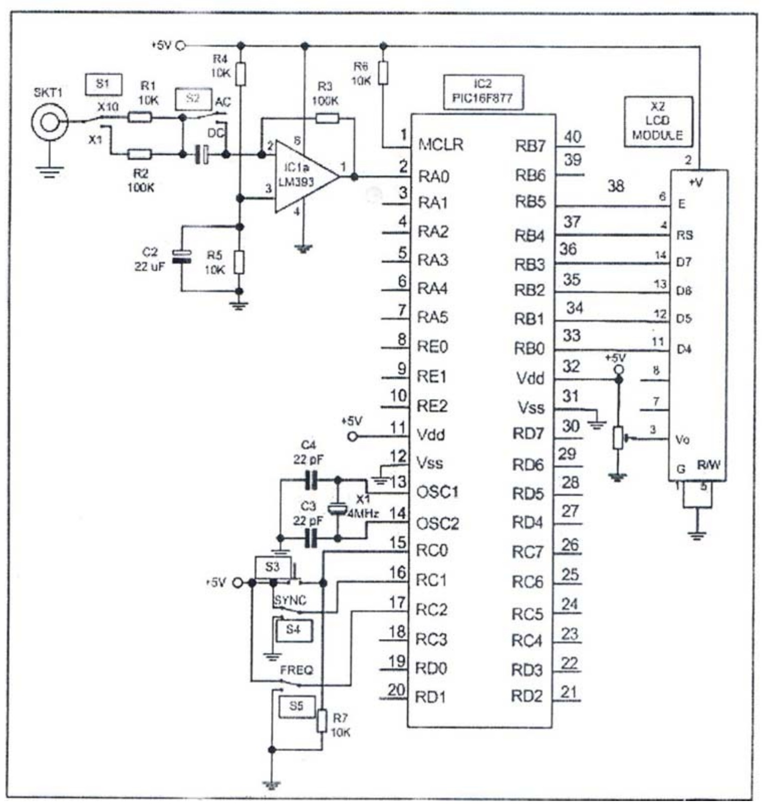

Figure 4. Complete circuit diagram

Testing

Before plugging the ICs into their sockets, the 5V supply is checked. When the power supply is correct, IC1, IC2 and LCD are plugged correctly. Then set switch S4 (Sync) off and S5 (frequency) on. When power is applied, the PIC first goes into an LCD initialization routine, in which it sets the LCD for 2 line 4-bit modes. Following this, text messages similar to those in the photographs appear. The signal trace display in the top left LCD character cells will show a straight line. When a signal is fed to the input, the waveform of the signal will be displayed with the voltage in peak-to-peak value as shown Figure 7 in the photograph.

Result and Discussion

The oscilloscope is a prime example of a design idea whose implementation was greatly simplified by using PIC 16F877. Test measurement are made and compared with the measurements with the real oscilloscope. The results are shown in Table 1 and Table 2. This oscilloscope displays the frequency and peak-to-peak voltage of the input signal nearest to the measurement results of the actual oscilloscope. The waveform of the signal displayed by the LCD is not accurate waveform as the original but can be distinguished between sine and square wave. This design is just to show that virtual oscilloscope using PIC 16F877. By using wide-screen LCD display such as 128 characters with 4 lines or graphic LCD display.

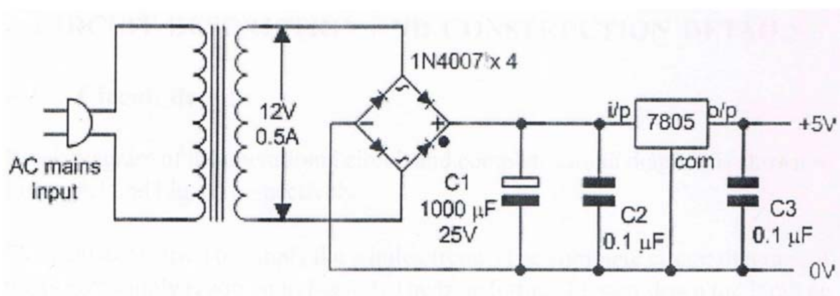

Figure 5. The complete circuit diagram of the power supply

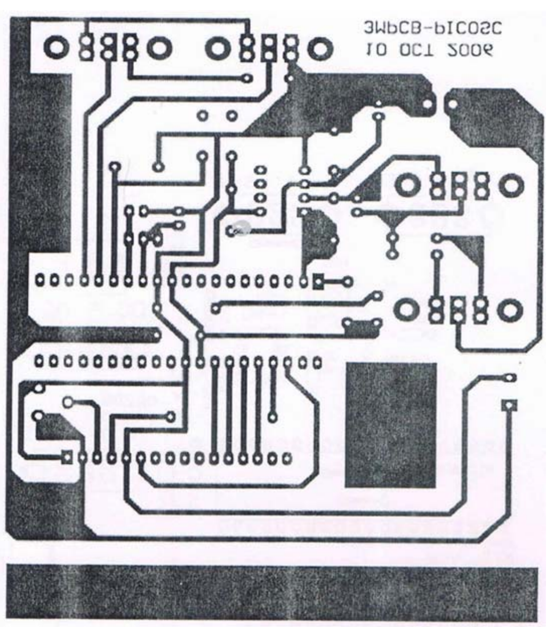

Figure 6. Bottom layer of PCB

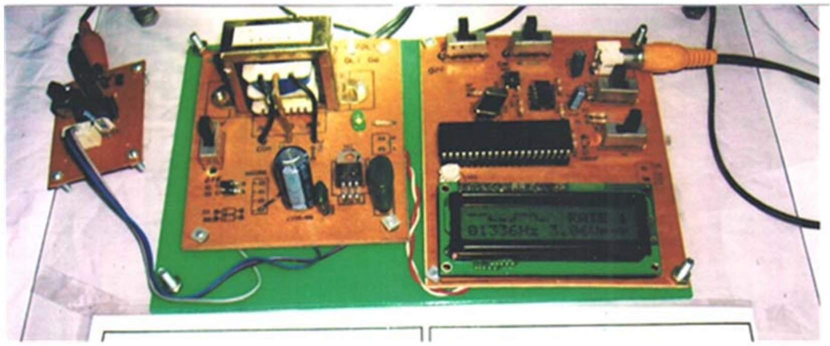

Figure 7. Complete unit of Virtual oscilloscope using PIC microcontroller

Table (1). Output Frequency of the Virtual Oscilloscope for Square Wave

Input Frequency	Output Frequency		
	Rate 0	Rate 1	Rate 2
100 Hz	103 Hz	100 Hz	102 Hz
1 kHz	988 Hz	962 Hz	972 Hz
10 kHz	9392 Hz	9137 Hz	9214 Hz
20 kHz	18238 Hz	9751 Hz	19800 Hz

Table (2). Output Frequency of the Virtual Oscilloscope for Sine Wave

Input Frequency	Output Frequency		
	Rate 0	Rate 1	Rate 2
100 Hz	99 Hz	95 Hz	97 Hz
1 kHz	988 Hz	964 Hz	976 Hz
10 kHz	9394 Hz	9147 Hz	9204 Hz
20 kHz	18099 Hz	9612 Hz	19230 Hz

Conclusion

In this work, this design is to show the virtual oscilloscope using PIC microcontroller. By using wide-screen LCD display such as 128 characters with 4 lines or graphic LCD display, this research can be improved by using that type of LCD if it is available.

Acknowledgements

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