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Peripheral Interface Controller - Based Frequency Meter

Htar Htar Aye Win[1], Thida Soe[2] and Ni Ni Yin[2]

Abstract

The digital frequency meter is designed and constructed by using PIC16F84A, IC4017 decade counter and other circuit components. Pulses are counted by using Timer0 of PIC. The 8-bit hardware register is extended by software into a 24-bit pulse counter. Timing is based on a software loop of known execution period which is iterated by using a 16-bit loop counter. The clock speed of PIC in this circuit is 20MHz and it is generated by the crystal controlled oscillator. The frequency which can be measured by this circuit is 0Hz to 15MHz. In this work, the program is written in assembly language and MPLAB software is used to assemble the program. The HEX file is embedded in PIC using EPIC programmer.

Key words: Embedded System, Frequency Meter ,Microcontroller - Based Instrumentation

Introduction

The frequency meter is one of the essential instruments in an electronic laboratory. It plays in important for scientific researches especially in electronic instrumentation research. Of course, the frequency meter measures the number of oscillations or pulses during the standard interval in one second. Since earlier time, various types of frequency meter were designed and developed. At first, they were analog type and the display system was simply a moving coil type. For an analog type frequency meter, the input signal is averaged and the circuitry is complicated.

Later, the digital instruments were developed and favoured in researches as well as in applications. The main advantage of digital instruments is their reliability and precision in performance. Nowadays, digital frequency meters are very useful to measure a variety of frequency ranges accurately.

In this work, a digital frequency meter will be constructed by using a single-chip computer, microcontroller. It is constructed a simple frequency

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meter for frequency range, 0Hz to 15 MHz. We employed the TMR0 module to count the external signal.

The count value is converted to BCD format and then to 7-segment display format. The measured frequency value will be shown on the eight digit 7-segment LED display system.

Because of special feature of microcontroller, we can reduce the external components thus reducing cost, enhancing system reliability and reducing power consumption. In this work, we will use the PIC16F84A microcontroller of Microchip and the program will be developed using assembly language. Self-developed program is assembled to machine code by MPLAB software and then embedded in microcontroller as the firmware via the EPIC programmer.

Experiment

Basic Operation of Frequency Meter

The constructed circuit consists of Signal Conditioning Unit, PIC Microcontroller with Firmware, Digit Multiplexing and Switching Unit and display Unit.

The duties of signal condition unit is to amplify the coming input signal. The output signal form of this unit is in discrete form and ready for the next unit. The frequency range in which this unit operated is sufficient for the PIC microcontroller with firmware.

The microcontroller with firmware unit will be counted the number of pulse coming previous state. This unit converted the count values to BCD format codes for 7-segment display pattern. This unit masks the insignificant zeroes. This unit also generated the word 'Error' when the count frequencies exceeded 15MHz. This unit also supports to the next unit for resetting and clocking.

The digit multiplexing unit produces the digit selecting pulse and control current. The current amplifying and switching unit amplify the current coming previous state and switch on the 7-segment selecting previous state.

The display unit is the final output unit of frequency meter. It consists of eight digit 7-segment display. The block diagram of peripheral interface controller–based frequency meter is illustrated in Fig (1).

Operation of PIC-Based Frequency Meter

In this research the circuitry and operator of each section of the constructed frequency meter will be discussed in detail. The main sections of our constructed device are:

(i) signal conditioning unit
(ii) PIC with firmware
(iii) display multiplexing unit
(iv) current amplifying and switching unit
(v) display unit
(vi) regulated power supply unit.

Signal Conditioning Unit

This unit amplifies the input signal and it keeps the peak value of the output signal not to exceed the maximum level of V_{dd} of PIC. For the low frequency signals, the rise time is so long that it is not convenient to feed a digital device directly. In this work, the signal conditioning unit is also intended for wave shaving. This unit can perform the wave shaping for low frequency signals.

The main component of this unit is S9014 transistor. It is a low noise npn type general purpose transistor. The transistor is biased by using collector to base biasing method via R_b and also an emitter feed back resistor, R_e, is included. Thus, the performance of the unit is reliable for next stage, PIC16F84A. The coupling capacitor, C, blocks the dc value of the external source.

PIC with Firmware

This unit is the main part of the system. The main component of PIC16F84A which receives the signal performs the required calculations and drives the visual display unit. Here we will discuss this unit as the following sections;

(i) Software Section

(ii) Hardware Section.

Software Section

In this work, frequency measuring is made by timer0 module of PIC16F84A and the counting period is 1 second (1000000μs). The program

for this operation is written using assembly language. The main tasks are counting, number conversion, pattern conversion, masking the unwanted zeros, out of the range error displaying and display driving. The signal is counted during the standard period 1 sec and the display unit is driven during this 1 sec to show the result frequency of the previous counting period.

The counting period 1 sec is created by processing the 5000000 instruction cycles definitely. Since the processor speed of μC constructed circuit is 20MHz, the time for one instruction cycle is 0.2 μs. In this way we can attain precise 1sec. In this case, the display driving, clocking and resetting the multiplexer and reading the timer0 module are accomplished during this 1 sec.

Hardware Section

This section is using PIC16F84A microcontroller IC. This section is energized by 5V power supply of voltage regulator section to V_{dd} and V_{ss} is connected to ground. The crystal is joined between the OSC1/CLKIN and OSC2/CLKOUT pin of the PIC microcontroller and then the capacitor C_1 and C_2 is connected to the ground. This section is connected to the signal condition unit, display unit, multiplexing unit .

Digit Multiplexing Unit

TC4017 decade counter/divider with 10-decoded output, is used to construct the digit multiplexing unit. This unit is clocked from the PIC with firmware. Resetting of 4017IC is also controlled by the PIC with firmware. The output of this unit is supplied to the current amplifying and switching unit.

Current Amplifying and Switching Unit

The duty of this unit is to amplify the current and to energize the display unit. The S9014 transistors are used as amplifying and switching unit. The transistor is biased by using common collector configuration with 220 Ω resistor. The base terminal is connected to the multiplexing unit and the collector is connected to voltage supply. The emitters are also connected to the common anode of the display unit.

Display Unit

This unit consists of eight pieces of 7-segment display. It is performed the counting value on it as decimal number.

Voltage Regulator

Since the power supply recommendation for PIC16F84A is +5V constant, L 7805 regulator is used for regulation. It is required to provide at least 6V as the supply voltage for L7805 IC. The two 10 μF capacitors are included to perform as the filters so that unwanted voltage fluctuations are eliminated.

Result and Discussion

Testing the constructed instrument is done by using a signal generator and MODEL 253 FREQUENCY COUNTER. The input signal is generated by a signal generator and fed to the constructed instrument as well as FREQUENCY COUNTER. The results of frequency values are shown in Table (1) and (2).

The experimental testing is made for 0 Hz to 50kHz of signal frequencies. The results of frequency values are the same under 40kHz and, above 40kHz , the frequency values are little deviation (0.017 %). Therefore, we expect that the constructed frequency meter is a reliable instrument for intermediate frequency values (less than 50kHz) and it can be very useful for audio signals analysis. The whole circuit diagram of PIC based-frequency meter is shown in Fig(2) .The printed circuit board is shown in Fig(3).The complete circuit is shown in Fig (4).

Table(1) Comparison of Constructed Frequency Meter and Frequency Counter (253)

Frequency Counter (Hz)	Constructed Frequency Meter(Hz)	Deviation (%)
0	0	0
10	10	0
20	20	0
30	30	0
40	40	0
50	50	0
60	60	0
70	70	0
80	80	0
90	90	0
100	100	0
200	200	0
300	300	0
400	400	0
500	500	0
600	600	0
700	700	0
800	800	0
900	900	0

Table (2) Comparison of Constructed Frequency Meter and Frequency Counter (253)

Frequency Counter (kHz)	Constructed Frequency Meter (kHz)	Deviation (%)
1	1	0
2	2	0
3	3	0
4	4	0
5	5	0
6	6	0
7	7	0
8	8	0
9	9	0
10	10	0
20	20	0
30	30	0
40.637	40.633	0.0098
40.993	40.986	0.017

Conclusion

A digital frequency meter is designed and constructed by using PIC16F84A and some electronic components . The constructed system is designed to measure the frequency values up to 15MHz .The testing is made by measuring various signal frequencies up to 50kHz . The result value is displayed on 8-digit display system and the unit of result value is hertz (Hz). The cost of the system is low and its performance is reliable.

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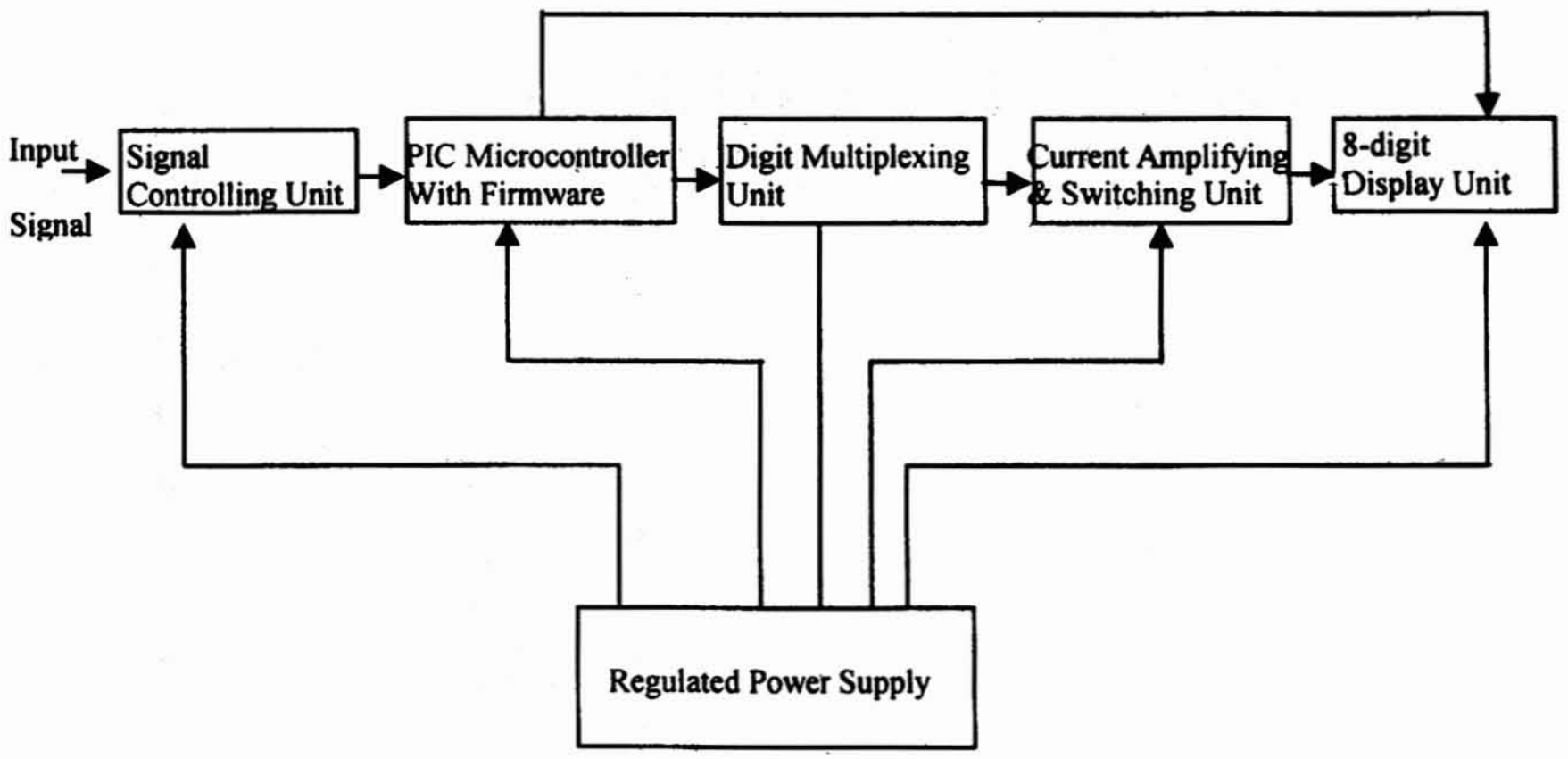
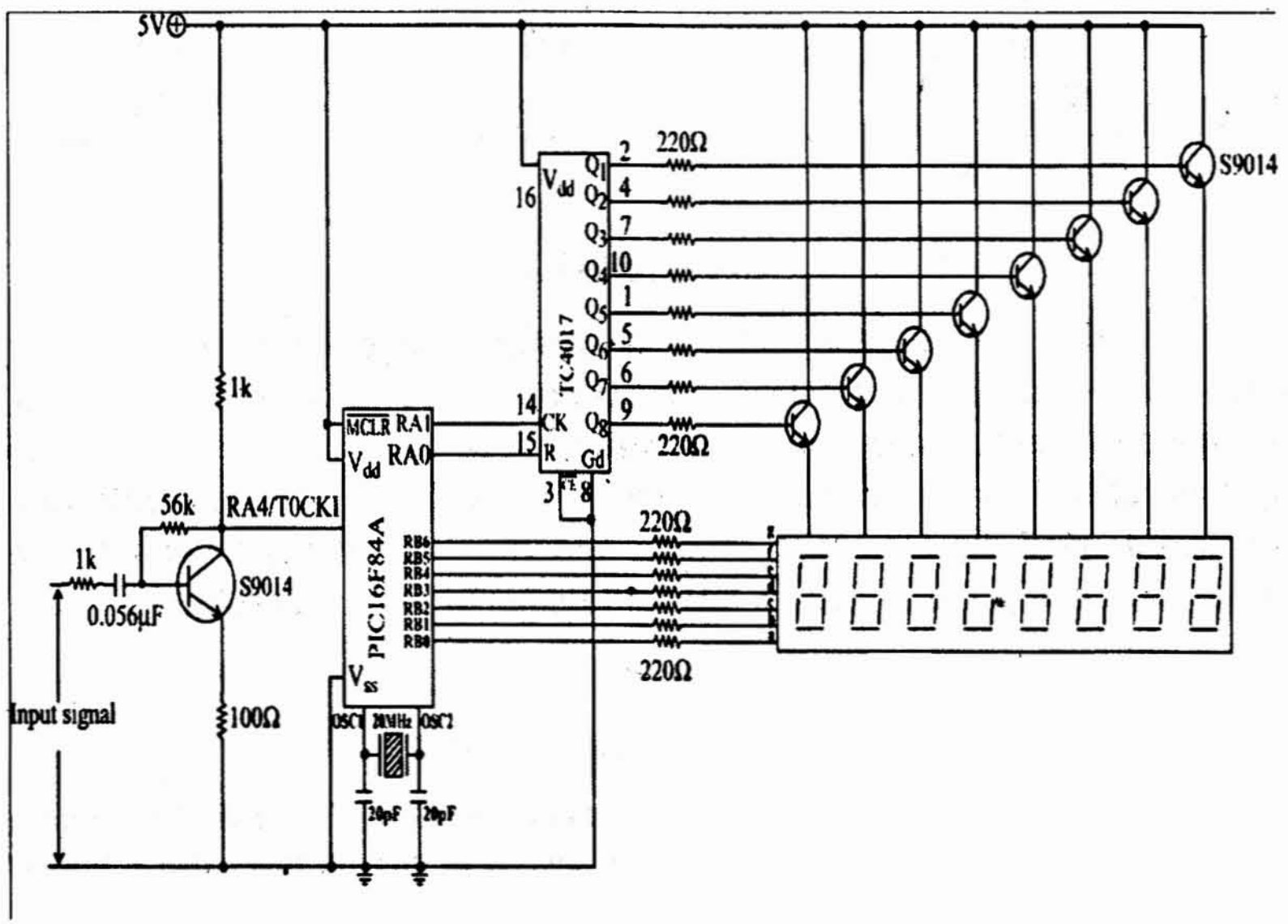


Fig(1) Block Diagram of Peripheral Interface Controller-Based Frequency Meter



Fig(2) Circuit Diagram of PIC-Based Frequency Meter

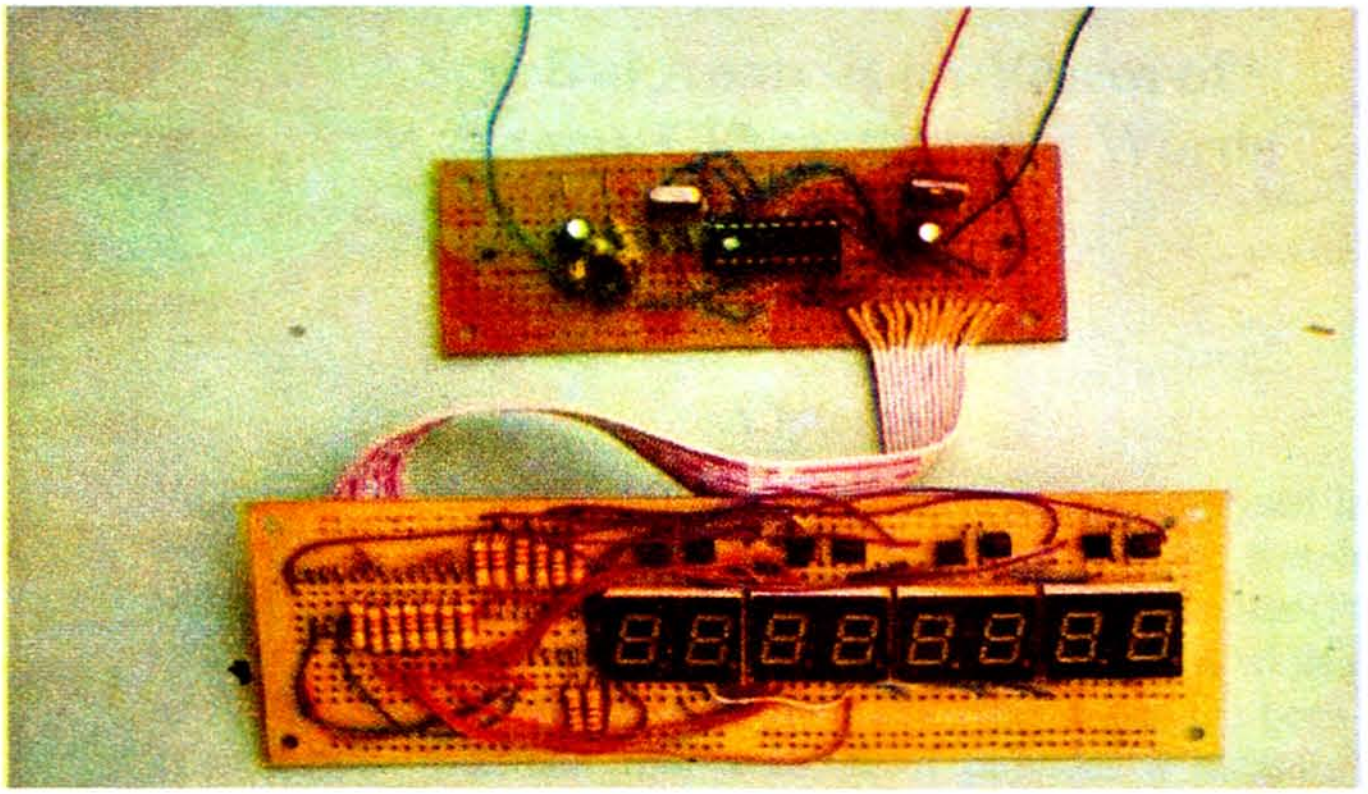


Fig (3) The Printed Circuit Boards

Fig (4) The Complete Circuit of PIC-Based Frequency Meter

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