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A Real Time Monitoring Approach for Pulse Counting Using Embedded Design Techniques

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Abstract

In the era of frequency counting there is a need of very accurate count and high resolution. In case of biomedical instrumentation slightly change of frequency can take the life of the human being. This paper proposes a highly accurate frequency counter using PIC 18F452. It can be used as workbench instrumentation. It has the facility to use in both cases (analog and digital) without changing the circuitry. In fact it has several useful features, like a 1. maximum frequency it can count is above 40 MHz; 2. It has 10 Hz resolution; it has very low power consumption (15 mA); and 3. It has very simple coding. This paper present a design for a simple, low-cost digital/analog frequency counter with the following features: it has operating range from 15Hz to 40MHz (sufficiently high to make the pic based counter useful for troubleshooting digital/analog circuits, microcontrollers etc.) ; it has internal accuracy ± 1Hz; it has 4 digits of displayed accuracy (enough accuracy for most situations); it is an adaptive (no range switch); it has 50mv input conditioning amplifier sensitivity; it protects input; it is a crystal controlled (therefore no need for calibration); it has only 9V alkaline battery for power supply.

Introduction

Frequency is the number of occurrences of a repeating event per unit time. It is also referred to as temporal frequency. The period is the duration of one cycle in a repeating event, so the period is the reciprocal of the frequency. For cyclical processes, such as rotation, oscillations, or waves, frequency is defined as a number of cycles, or periods, per unit time. In physics and engineering disciplines, such as optics, acoustics, and radio, frequency is usually denoted by a Latin letter f or by a Greek letter ν (nu) (Barsoum, 2007).

In SI units, the unit of frequency is hertz (Hz), named after the German physicist Heinrich Hertz. For example, 1 Hz means that an event repeats once per second, 2 Hz is twice per second, and so on. This unit was originally called a cycle per second (cps), which is still sometimes used. Heart rate and musical tempo are measured in beats per minute (BPM). Frequency of rotation is often expressed as a number of revolutions per minute (rpm). BPM and rpm values must be divided by 60 to obtain the corresponding value in Hz: thus, 60 BPM translates into 1 Hz (Biehl, 1995). The period is usually denoted as T, and is the reciprocal of the frequency f:

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$$T = \frac{1}{f}$$

Other types of frequency

Angular frequency ω is defined as the rate of change in the orientation angle (during rotation), or in the phase of a sinusoidal waveform (e.g. in oscillations and waves):

$$\omega = 2\pi f$$

Angular frequency is measured in radians per second (rad/s).

Spatial frequency is analogous to temporal frequency, but the time axis is replaced by one or more spatial displacement axes. Wave number is the spatial analogue of angular frequency. In case of more than one spacial dimension, wave number is a vector quantity (Jones and Blackwell, 1983).

Measurement

By timing

To calculate the frequency of an event, the number of occurrences of the event within a fixed time interval are counted, and then divided by the length of the time interval. In experimental work (for example, calculating the frequency of an oscillating pendulum) it is generally more accurate to measure the time taken for a fixed number of occurrences, rather than the number of occurrences within a fixed time. The latter method introduces — if N is the number of counted occurrences — a random error between zero and one count, so on average half a count, causing a biased underestimation of f by $\frac{1}{2} f / (N + \frac{1}{2})$ in its expected value. In the first method, which does not suffer this particular error, frequency is still calculated by dividing the number of occurrences by the time interval; however it is the number of occurrences that is fixed, not the time interval (Li, *et al.*, 1995).

By stroboscope effect, or frequency beats

In case when the frequency is so high that counting is difficult or impossible with the available means, another method is used, based on a source (such as a laser, a tuning fork, or a waveform generator) of a known reference frequency f_0, that must be tunable or very close to the measured frequency f. Both the observed frequency and the reference frequency are simultaneously produced, and frequency beats are observed at a much lower frequency Δf, which can be measured by counting. This is sometimes referred to as a stroboscope effect (Reinert, *et al.*, 2000). The unknown frequency is then found from

$$f = f_0 + \Delta f$$

Case Study

Block diagram of PIC based frequency meter (FM) is shown in figure 1 and PIC based FM is shown in figure 2. Whole system may be divided into four stages. First stage is concern with the conversion of incoming voltage and current into the PIC level voltage (e.g. 5V). Here we have to use the step down arrangement like step down transformer; it is shown in figure 2.

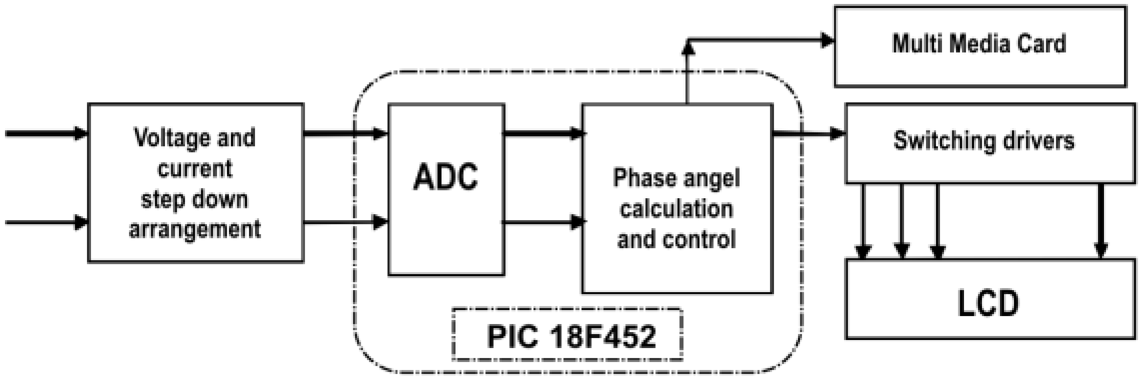

Figure 1: Block diagram of PIC based FM

Whole system is divided into four stages: At first we step down the voltage from higher range to PIC range with the help of step down transformer. In this step we take line current before the system in form of voltage and voltage across the system so that we can find out the leading or lagging angle; Second stage is concerned with conversion of analog to digital signal. This is done by use of PIC. In this stage we calculate the phase angle between current and voltage that is continuously displayed on LCD as shown in figure 2. The digital voltage acquired are processed in the PIC with the help of appropriate algorithm realized in its software; In third stage we store the all variances of frequency in MMC card that will be used in future for analysis; At final stage we can use it for different purpose using switching circuit. Each cycle is repeated by 1 second so that it can store all varience.

PIC 18F452 suits well to perform these tasks because of its following feature: It has built in 10-bit Analog-to-Digital Converter module (A/D) with fast sampling rate approximately 0.632 MHz and good linearity ($\leqslant 1$ LSb). It has high current sink/ source (25 mA) for digital input/output. It has 3 external interrupt pins and four timer module, namely: Timer0 module: 8-bit/16-bit timer/counter with 8-bit programmable prescale; Timer1 module: 16-bit timer/counter; Timer2 module: 8-bit timer/counter with 8-bit period registers (time-base for PWM); Timer3 module: 16-bit timer/counter. One major reason for selecting 18F452 is its library support for interfacing multimedia card (MMC) drivers. A single command is required to write or read any data from MMC.

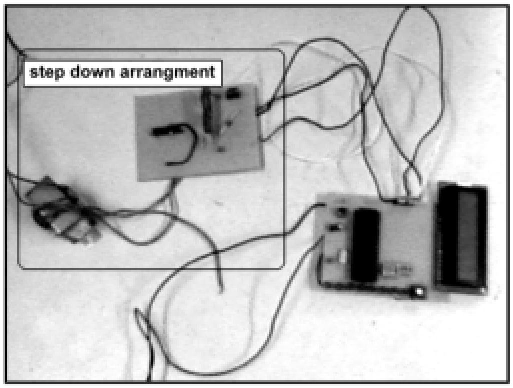

Figure 2: Picture showing PIC based FM

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Problem Formulation

Algorithm for determining frequency

Step 1- Check for voltage cross zero from negative to positive.

Step 2- Timer T starts (T).

Step 3- Check again for voltage cross zero from negative to positive.

Step 4- Timer T stops.

Step 5- Frequency= 1/ T

Step 6- Get the frequency with units from look up table.

Simulation and Testing

Test the voltage level and current level

First step is to step down the voltage from higher level to 4V to 5V level which is suitable for PIC. Outcome of input voltage after passing through the diode before enters into pin port (A1 & A2), the diode clipped the negative portion of the sine waveform so that to prevent PIC take in excessive negative voltage. The outcomes are shown in the fig 4 and fig. 5.

At the same time, it drains some voltage hence channels waveform is slightly lower. A shunt resistor of any value must be connected after the diode and link to ground, this prevents harmonic appears.

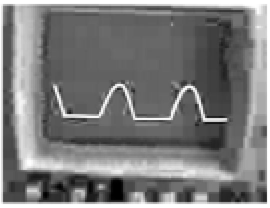

Figure 3: Voltage waveform after diode

Detecting zero crossing

We take the analog channel 1(A1) for current and analog channel 2(A2) for voltage as shown in figure. These analog channels are connected to the analog to digital conversion (ADC) module. ADC module converts the analog signals to the 10 bit digital value using successive approximation method. For zero crossing, we write the program and take the current and voltage value from ADC module. We take the value of count which depends upon the prescale value. Table shows the prescale values and respective count values.

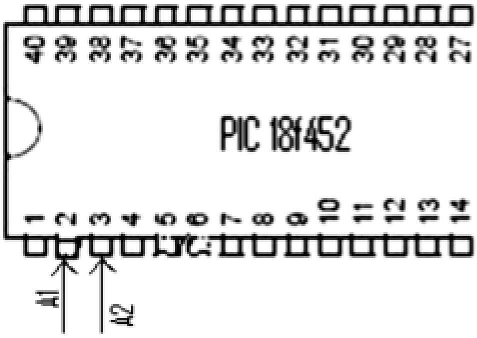

Figure 4 : Connection with analog channel 1 and channel 2

We start timer when first zero crossing is detected and stop timer when second zero crossing is detected. In between first zero crossing and second zero crossing count is continuously increased then we find out the no. of count between both zero crossings. It gives the value of time period. Time period is shown in figure. We set the timer0 at 101desimal value and we take the prescale value as 1:4. Due to the higher prescale the degree of accuracy increases. This prescale value and timer initial value defines the timer roll over time. As the timer rolls from FF to 00, the count increases by one. At this prescale one count is equal to 3.125 x 10^{-4} second.

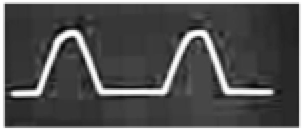

Figure 5: Time period as zero crossing system.

In this work user can also define the range of frequency so that beyond the range there is a provision to alert the user in case of medical science. The system design implementation and testing is divided into five major parts: Test the voltage level; detecting zero crossing; Finding time duration; frequency calculation; Physical testing of frequency meter. Bold row in table 1 is used during the calculation of power factor. We display the value of count at LCD. There is no need of any types of zero crossing circuit or comparator circuit. In 18 series PIC there is no comparator facility so we only use the timer and ADC mode to find out the time period and frequency. Prescale is defining the resolution of the frequency meter, as the prescale value is increased the accuracy is increased. So why we are using higher prescale value.

Result and Discussion

In this work, frequency is counted by PIC 18F452. Here two facilities are mentioned; one is to store the all variances in the frequency and second is to take the action according to the requirement like alarm.

Table 1: Comparing count with pre-scale

Pre-scale value	Count	Count for 1 sec	Frequency
1:2	128	6400	50Hz
1:4	64	3200	50Hz
1:8	32	1600	50Hz
1:16	16	800	50Hz
1:32	8	400	50Hz
1:64	4	200	50Hz
1:128	2	100	50Hz
1: 256	1	50	50Hz

Conclusion & Future Work

This Paper work is an attempt to design and implement the frequency meter using PIC micro controller. In this work there is a provision to define the own frequency range. PIC monitors frequency continuously and then according to the lagging or leading frequency it takes the control action. This paper gives more reliable and user friendly frequency meter. This paper makes possible to store the real time action taken

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by the PIC microcontroller in MMC card. This paper also facilitates to monitor the frequency changes on LCD in real time. It can be enhanced for different part of human body so that it helps the physician to diagnose.

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