# DESIGN OF A FREQUENCY MEASUREMENT SYSTEM FOR ASTROPHYSICAL APPLICATIONS

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**Abstract:** This work describes the most important characteristics of a high precision instrument for the measurement of the oscillation frequency of a quartz microbalance, designed and constructed in the Laboratory of Experimental Astrophysics of the Universidad Politécnica of Valencia

## 1 Introduction

In the Laboratory of Experimental Astrophysics of the Universidad Politécnica of Valencia, we carry out experiments in order to measure the density and the refraction index of ices having a remarkable astrophysical interest [1] due to the presence of pure or mixed molecules like $CO_2$, $N_2$ and $CH_4$. The presence of these composites is very outstanding both in the interstellar medium [2] and in the Solar System (Mars, Neptune,Pluto) [3] [4].

In a first step of our experiment, we introduce the substance, in gaseous form, inside a ultrahigh vacuum chamber ( $10^{-7} mbar$), where it condenses in ice form when contact with a cold finger (10 K) takes place. Its density can be calculated from the thickness of the deposited ice and by its mass.

The thickness of the ice, together with the refraction index, is calculated through two lasers He-Ne having different angles of incidence and whose interference patterns are read off during the growth of the ice. The mass of the ice is calculated with a quartz microbalance, a LC oscillating system situated in the chamber above the glove finger. The procedure of measurement consist in determining the frequency changes with the mass deposited on the quartz crystal.

In order to achieve good quality data, the precise calculation (until units of Hz) of the oscillation frequencies of the quartz is needed. It is possible to find in commercial form systems of this nature, based in the same principle, but with very high prices. This is one of the reasons why we decided to develop our own system.

# 2 Description of the quartz microbalance system

Basically, the system is an oscillating circuit with a crystal of quartz fitted inside the deposit chamber.

The ice, object of research, forms on the top of the crystal. The frequencimeter measures the frequency of the signal coming form the oscillator. The frequency data, together with the two laser interference data, are recorded in a computer. In the following sections, we describe every element of our micro-balance of quartz.

## 2.1 Oscillating circuit

Figure number 1 shows the schema of the Colpitts oscillator [5] [6], used to determine the mass deposited on the crystal of quartz. The common-collector input configuration of the oscillator barely gives the crystal a charge. Since the nominal frequency of the quartz is of 6 MHz, C1/C2 has to stay between 560 and 470 pF. Taking the crystal to his nominal frequency implies connecting a pre-set condenser at 30 pF in series with the quartz.

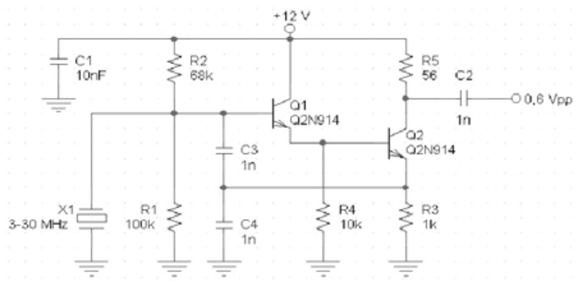


Figure 1: Colpitts oscillator from 3 to 30 MHz.

## 2.2 Frequencimeter

The schema of the system [7] [8] appears in Figure 2. The frequency signal which has to be measured is processed through an amplifier and a trigger Smith which transform the frequency in a series of pulses with the same frequency, applied to an AND port. The time setting gives the impulse to the opening and the closing of the port with a skip factor of 1 second.

A high stability and precise temperature-compensated oscillator of quartz gives the impulses for opening and closing and its circuit supplies a totally TTL-compatible output. Nominal stability is 1 p.p.m. The signal passes through several cascade serial dividers; the last one generates a 50 percent duty cycle signal, in order to obtain a

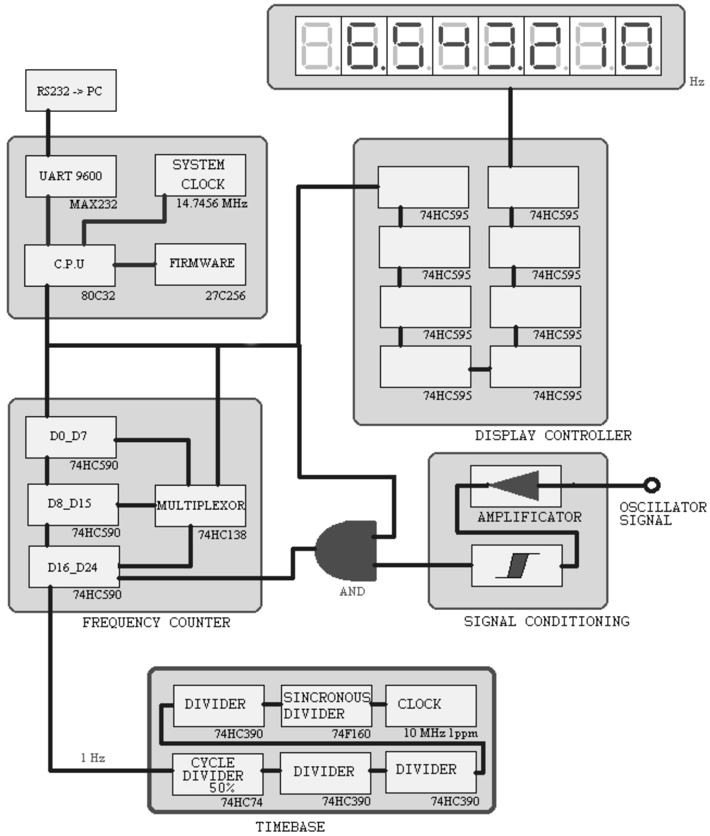


Figure 2: . Block diagram of the frequencimeter.

1 Hz frequency. While the port is open, the counter records the number of pulses coming from the trigger circuit and passing through the port. When the port closes, the counter stops.

The number of pulses divided by the time gives the frequency.

We used a 24 bit (74HC590) synchronous counter, with a highest reachable value of 60 MHz. The outputs, in binary system, are converted in decimal system by a processor and then showed at the screen. The number of possible results is 224 so that the maximum reachable frequency with this setting is within 0 and 16.777.216 Hz. The processor cleans the counter after every counting and the bytes are read by the data bus. The multiplexor chooses the bytes in the counter. To avoid using internal timers that would cause a bigger error in the counting, the hardware is checked by the micro controller.

Once the measure is done, it is send to the computer through the RS232 port. A software developed by us in Labview language, performs the data adquisition and integrates the whole experiment measurements.

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