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# Method and System for Time Interval Measurement

OSIM Patent Application 2011

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## Purpose

**The goal of the invention is to find a new method implementable on common microcontrollers for measuring time intervals with a precision which is significantly better than that which is normally obtainable using direct counting of the clock pulses.**

## Objective

The main objective of the patent application is to present an auxiliary method for time measuring which in combination with the direct counting method results in compensating each others disadvantages in obtaining high measuring precision. The obtained hybrid method is suitable for microcontroller implementation using no active or semiconductor external components.

## Concept

### State of the art for time measuring

Methods are:

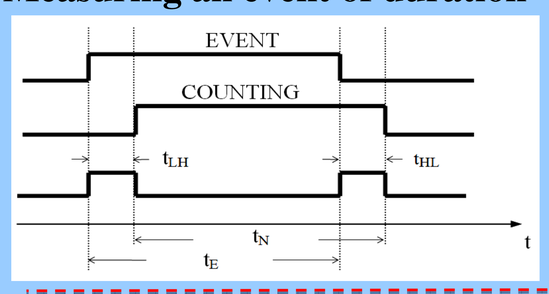
- accurate but expensive to implement – i.e. Vernier method
- cheap but less precise – i.e. counting method
- precise but limited in maximum measurable interval – i.e. time-to-voltage method

### Description of the new solution for time measuring

Use a hybrid method that mix direct counting and time-to-voltage methods obtaining the following **advantages**:

- implementable on cheap microcontrollers that include a TIMER and an ADC
- high precision in time intervals measurement using common ADCs (< 10 ns)
- increased limit of the measurable time intervals

### Measuring an event of duration




$t_N$ - measured using direct counting method

$t_{LH}$, $t_{HL}$ - measured using time-to-voltage method

- event duration is obtained as:

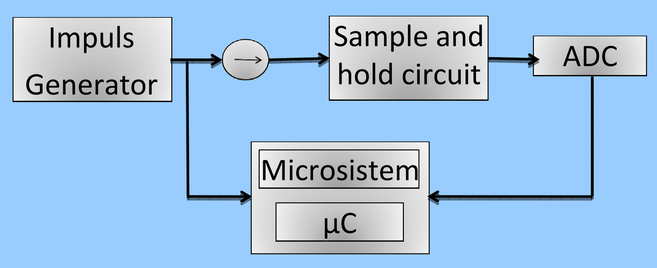
$$t_E = t_N + t_{LH} - t_{HL}$$

## Hybrid method implementation

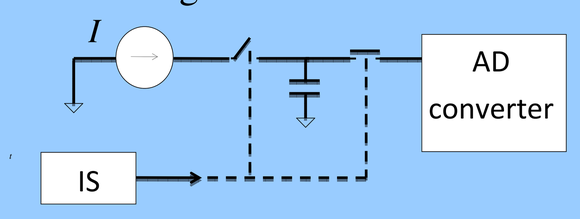
The time-to-voltage method is implemented using an AD converter and a sample and hold circuit for estimating the elapsed time passed between:

- EVENT onset and start counting
- EVENT offset and stop counting

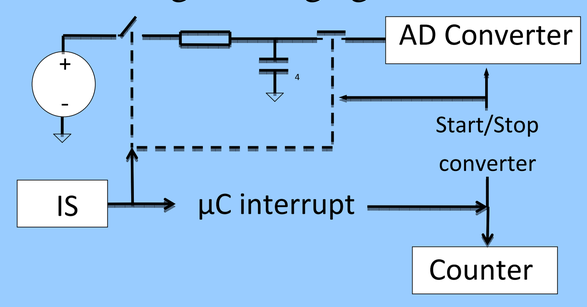
- **Measuring system schematic diagram:**




- Using constant current source

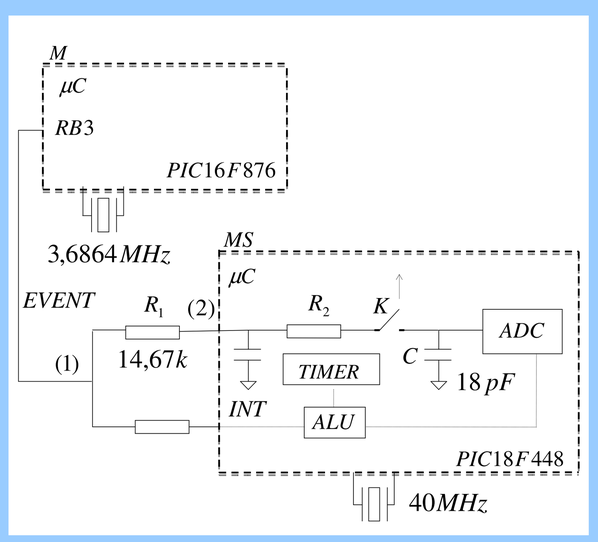



- Using a voltage generator:




## Results

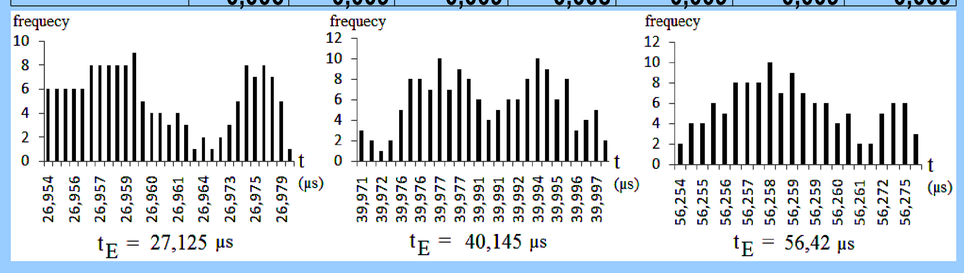
For testing the new concept we estimate the time measuring error when for ***time interval measuring*** we used a microcontroller PIC18F448 which receives the ***events*** from a PIC16F876 microcontroller.




Measuring micro-system

**System measurement performance for several time intervals**

| Interval (µs) | 14,105 | 17,36 | 20,615 | 23,87 | 27,125 | 40,145 | 56,42 |
|---|---|---|---|---|---|---|---|
| Accuracy (µs) | 0,166 | 0,164 | 0,163 | 0,163 | 0,162 | 0,159 | 0,157 |
| Precision(µs) | 0,006 | 0,009 | 0,009 | 0,008 | 0,009 | 0,009 | 0,009 |




**Measurement histograms**

Presents the time distribution for the events durations – $t_E \in \{ 27.125 ; 40.145; 56.42\}$ µs when every event was generated and measured 150 times. The event generator errors were insignificant for the desired measuring precision.

## Advantages

**•The time measurement *precision* for all considered intervals is less than 9 ns.**

**•The use of hybrid method improved 22 times the measurement precision of the counting method.**

**• By calibrating the system in order to eliminate the systematic error the measurement *accuracy* for the considered intervals is 18ns.**

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