Data acquisition system for quasidigital sensors

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Abstract- Actually, quasidigital sensors are become very important in noisy environments. In order to learn how quasidigital sensor works, the target of this paper is to design a data acquisition system based on a computer and a PCI (NI Pci-6221) data acquisition board to acquire data from SMT160 quasidigital temperature sensor using the ELVIS platform and Labview as a language programming software. In addition the Universal Transducer Interface from Smartec will be evaluated as an analog to frequency converter for resistive and capacitive sensors. The objective of this present paper is to study and to realize a practical application that can be called a revolution in the sensor application because it doesn't need any additional elements or any signal acquisition: UTI (Universal Transducer Interface)

I. Introduction

Advance knowledge of silica and other semiconductors and the technological fabrication of the microcircuits permit to integrate much function in the same circuit's whit common support.

The digital processor connected to several of sensors combine their output to obtain the information or desire response to extend the possibility of indirect measurements. The tendency is to make sensors whit digital output or quasidigital and since there are little sensors of this type, the immediate digitalization, whit microcontroller is the next option to have That way is better to consider the base of the digitalization a digital counter, so in case of modulators sensors we can use a variable oscillator for signal acquisitions. The UTI is a direct interface sensor-controller whit low cost and permits a direct connection to a great variety of sensors. Figure 1

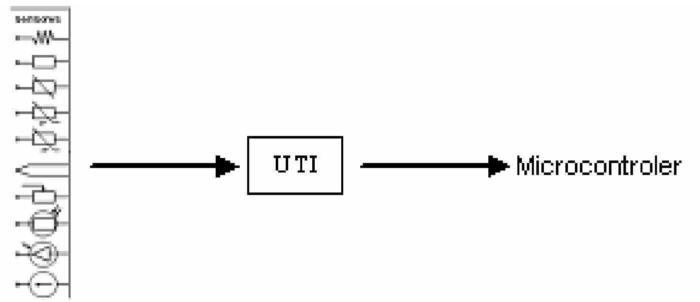

Figure 1. The UTI interface sensor-controller

The Universal Transducer Interface (UTI) is a complete analog front end for low frequency measurement applications, based on a period-modulated oscillator. Sensing elements can be directly connected to the UTI without the need for extra electronics. Only a single reference element, of the same kind as the sensor, is required.

The Smartec temperature sensor is a sophisticated full silicon temperature sensor with a digital output. The one wire output (duty-cycle modulated) can be directly connected to all kinds of micro-controllers without the need of A/D conversion. The temperature range is –45 °C to 150 °C. The high resolution (< 0.005 °C) makes the sensor useful for high precision applications.

A. Three-signal technique and calibration

The three-signal technique is a technique to eliminate the effects of unknown offset and unknown gain in a linear system. In order to apply this technique, in addition to the measurement of the sensor signal, two reference signals are required to be measured in an identical way.

Suppose a system has a linear transfer function of:

$$M_i = kE_i + M_{off} \tag{1}$$

Measured three signals are:

$$\begin{aligned} M_{off} &= M_{off} \\ M_{ref} &= kE_{ref} + M_{off} \\ M_x &= kE_x + M_{off} \end{aligned} \tag{2}$$

Then the measuring result is the ratio:

$$M = \frac{M_x - M_{off}}{M_{ref} - M_{off}} = \frac{E_x}{E_{ref}} \tag{3}$$

If the system is linear, then in this ratio the influence of the unknown offset M_{off} and the unknown gain k of the measurement system are eliminated. This technique has been used in the UTI.

The implementation of the three-signal technique requires a memory: A microcontroller is used to perform the data storage and the calculations, and to digitize the period-modulated signals. Such a system combining a sensing element (sensor), a signal-processing circuit, such as the UTI, and a microcontroller is called a microcontroller-based smart sensor system.

B. The Labview application program.

This application consists in a Labview program for the acquisition of the sign period of the output from the UTI and the output data is an array type and it is used for obtain the resistor value. The dates obtained are the semiperiods from the output signal from the UTI. In the figure 2 are the periods from the output signal which will be acquired whit the program.

The UTI is working in Mod 4 (capacity measurements) and Mod 6 (resistive measurement)

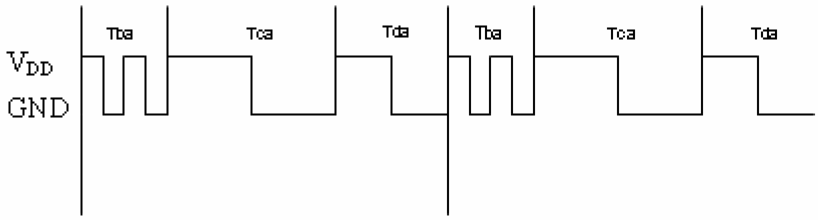

Figure 2. Periods from the output signal which will be acquired

In the 4 Mode 3 capacitors in a range of 300pF we have an output sign like in the previous figure whit three periods on cycle. Our program will measure the semiperiods for each of the cycle of the output signal. The first two semiperiods (the smaller one corresponds to T_{ba}), the third semiperiod is $T_{ca}/2$ and the fourth is $T_{da}/2$. Then the fourth semiperiod it will repeat cyclically. To calculate the C_x value which is the value we want to measure, it could be measure whit the formula:

$$M = \frac{C_x}{C_{ref}} = \frac{N_x - N_{off}}{N_{ref} - N_{off}} = \frac{T_{ca} - T_{da}}{T_{ba} - T_{da}} = \frac{T_2 - T_3}{T_1 - T_3} \tag{4}$$

Where: C_{ref} is 270pF.

T_{ca}, T2 is proportional to the capacity connected between C and A of the UTI terminals, in our case the capacity to measure is Cx.

T_{ba}, T1 is proportional to the capacity connected between B and A terminals of the UTI, in our case the reference capacity, C_{ref} which in our case is 270 pF

T_{da}, T3 is proportional to the offset of the system and the terminal D is not connected. T_{da} is always smaller then the other 2 periods.

In MOD 6, in our case, we have output signal like in the Figure 3 picture whit 4 periods on cycle.

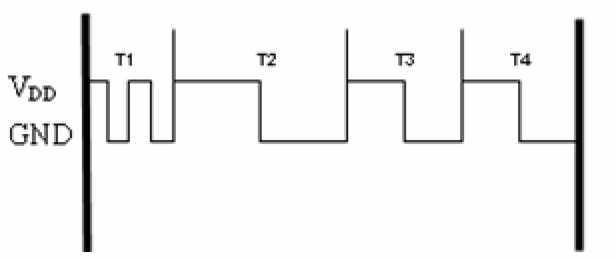

Figure 3. Output signal in Mode 6

Our program measure the output signal obtained 5 semiperiods: 2 belong to the T1 and the others three to T2, T3 and T4.

To calculated the value of the Rx, which is the resistance to measure, could by mediating formula:

$$M = \frac{R_x}{R_{ref}} = \frac{N_x - N_{off}}{N_{ref} - N_{off}} = \frac{T_3 - T_1}{T_2 - T_1} \quad (5)$$

Where:

- T3 is proportional to the measured resistance, Rx;
- T2 is proportional the reference resistance, R_{ref} which is 1kΩ;
- T1 is proportional to the offset of the system which it will be always smaller then the other two.

There are two different parts: the acquisition part and the processing data part.

Data acquisition:

First time was created an input cannel of counter type VI ¨DAQmx Create channel¨. To measure the width of the pulses, we configure the counter to measure the pulses: counter input→ pulse width.

Is important to put the values maxim and minim of the unknown period with precision so the DAQ automatically will choose the best base time to minimize the errors of the measurement witch in our case is 20 MHz.

The maximum value is the bigger time between 2 adjacent borders.

The minimum value is the smaller time between 2 adjacent borders from the signal from the input of the counter. Next we call the DAQmx Timing and we configure the implicit mode (for counters), this VI is used for configure the measure mod. Next we call the VI ¨START¨ to arm the counter and to start the measure.

To make continues measure the counter continuously read the dates until we push the STOP button from the Front Panel. The VI how reads the dates, saves them in to an array type in a VI ¨DAQmx Read¨. Once the task is done we call the VI ¨Clear task¨ to finish the roof the routine.

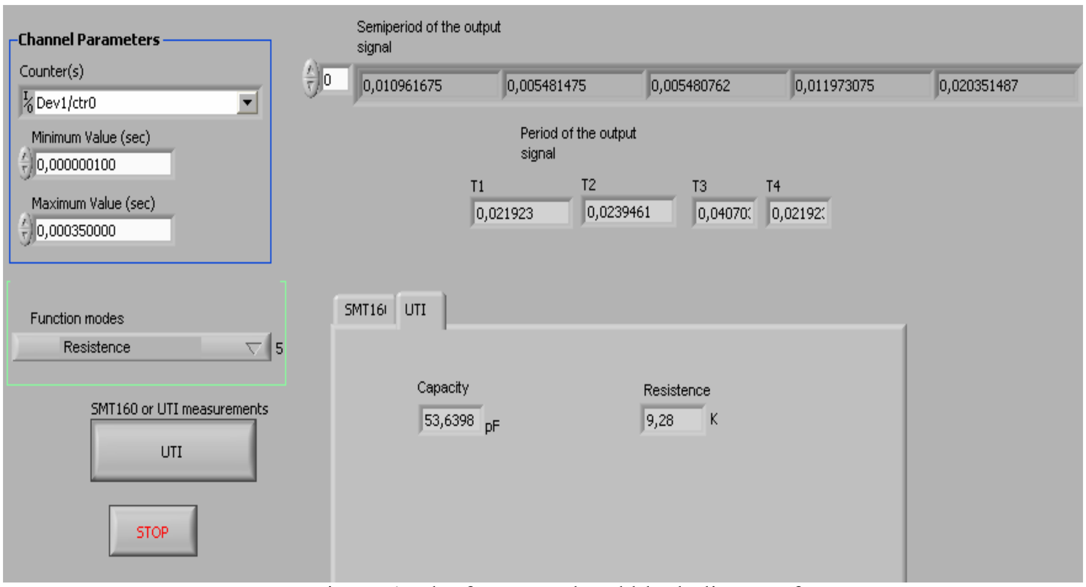

Figure 4. The front panel and block diagram for UTI

Once known the dates a formula is applied or another depends the mode that is needed (capacitor measure or resistance).

In figure 4 is presented the front panel which presents dependences between periods and resistant (capacity) components. In figure 5 is presented the block diagram

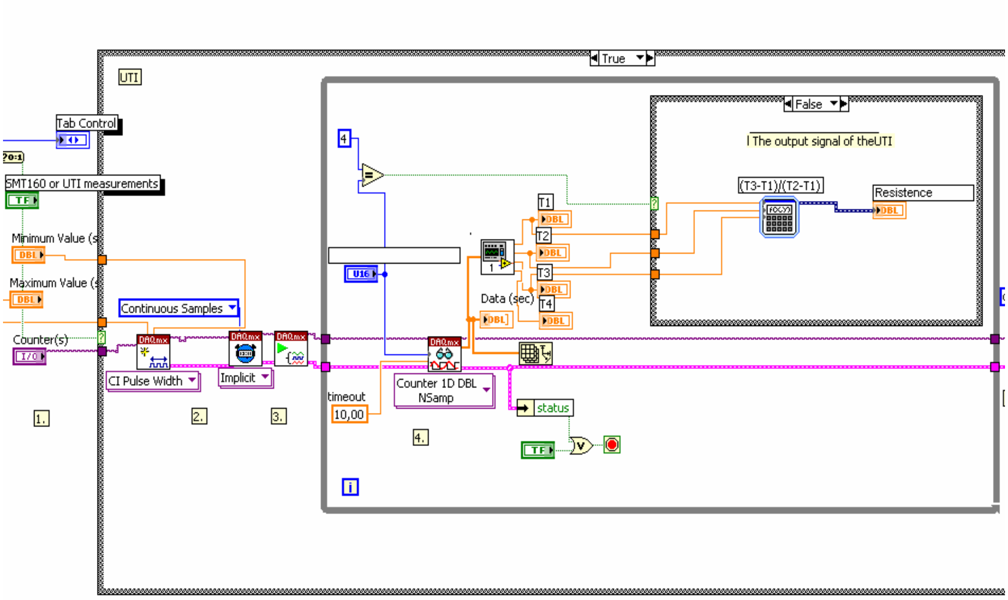

Figure 5. Block diagram of the system

II. Conclusions

Intelligent sensor interface is a rapidly expanding area of research, which will inevitably bring extraordinary changes in the current medical , industrial, avionics, consumer products, space research, manufacturing, and many other real life problems. Many scientists and engineers who are confronted with real life sensor problems agree that solution will only be found when an intelligent universal sensor interface, with standard outputs, can be produced. It. The UTI chips are available in the market and are costly and include high performance front-end circuits for resistive and capacitive sensors only.

" Universal Transducer Interface" of Smartec is the revolution to working with the sensors because is not necessary the acquisition of signal and additional elements. It is interface for different type of sensors, thermistors, PT100, PT1000, potentiometers. It is possible to connect different sensors to one chip to multiplexer input signals. It is just one alimentation source. It is an autocalibrated sensor and it uses the three signals technique and this way the profit and the offset are annulated. It has a maxim resolution of 14 bits.

The tendency now is to make sensors whit digital or quasidigital output and since there are not many sensors of this type. Tendency is to incorporated sensors in the same physical device whit all the electronics necessary, and this are called intelligent sensors.

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