THE NOISE PERFORMANCE OF EVALUATION BOARDS FOR A UNIVERSAL TRANSDUCER INTERFACE WITH USB CONNECTION

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When using toolkits and evaluation boards, it is very convenient to use the power source of a USB port to supply the connected devices. Often the output voltage of the USB port is somewhat noisy, which degrades the noise performance of high-precision devices. It has been shown that the use of a low-noise charge-pump DC/DC converter can help to overcome this problem. This solution has experimentally been evaluated for various designs of the evaluation boards for the Universal Transducer Interface UTI of Smartec. The results show that in this way the resolution can be improved with up to one bit and that the toolkits can work with a wide variety of PCs.

Keywords: Transducers, interfaces, sensor system.

1. INTRODUCTION

Universal Transducer Interfaces have been designed to enable rapid prototyping during research and development of new sensor systems [1-5]. Manufacturers of such interfaces often provide evaluation boards, which are connected to a personal computer via an RS232 communication port. However, at present it would be more convenient to communicate with a PC via an USB port. In addition, such a port can also deliver the required DC power supply for the evaluation boards.

Recently, Smartec [1] reported about problems with the release of a USB version of their evaluation toolkit for their Universal Transducer Interface [2]. In this kit, the evaluation board is directly supplied by a DC voltage delivered by the USB port. Unfortunately, it was found [2] that the USB versions of the boards were noisier than the RS232 ones. To solve this problem we developed a new evaluation board in which the DC voltage has been obtained with a low-noise charge-pump DC/DC converter. In this paper we present the results of experimental investigations of the features of three versions of the UTI evaluation boards, which are equipped with an RS232 communication port and a USB ports, with two types of voltage regulators, respectively.

2. MATERIALS AND METHODS

Figure 1 shows three versions of the evaluation board for the Universal Transducer Interface (UTI) chip, which is used for reading out and transferring the data to a computer. The board on the left is equipped with a RS232 communication port and was used as reference for the accuracy that can be obtained with the other boards. The USB board in the middle (Fig. 1) is directly powered by the USB port. The right-hand side of Fig. 1 shows the novel board in which the power of the USB port is regulated by a low-noise charge-pump DC/DC converter, which yields a low-noise regulated power source for a wide range of input voltages (2.7V to 5.4V).

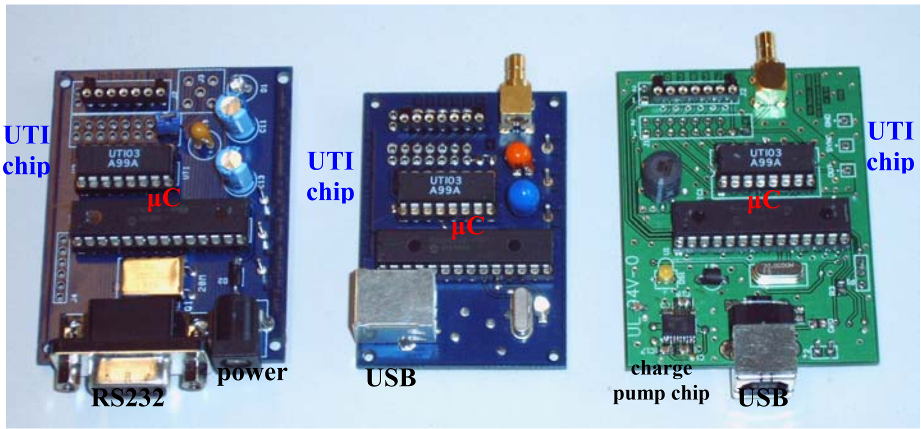

Fig. 1. Three evaluation boards for the UTI chip: (left) board with a size of 6.5cm × 5cm, with RS232 communication port and a power connector; (middle) board with a size 6cm × 4.2cm with USB port; (right) board with a size 6.5cm × 5cm, with USB port and a charge-pump DC/DC converter.

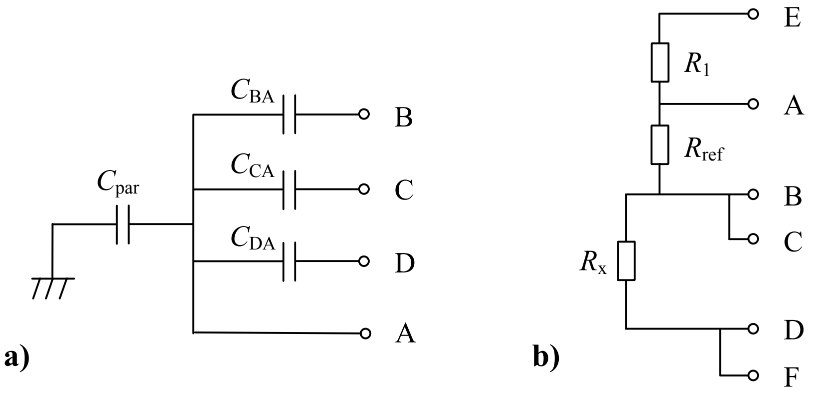

Fig. 2. Sensor and reference components connected to the UTI a) for capacitive measurements in mode1; b) for resistive measurements in mode 5.

The quality of these boards has experimentally been investigated for two UTI modes, where we used Labview to collect and display the data. For these two modes, the applied connections for the sensor and reference elements have been shown in Fig. 2. Figure 2a depicts the connections for capacitive measurements, which are applied for three sensor capacitors in the range of 0 pF to 2 pF (mode 1). During our tests, the capacitances $C_{BA} = C_{CA} = 1.8$ pF (nominal) and C_{DA} is open, thus equals the offset capacitance, which is measured for the purpose of auto calibration. The capacitance C_{par} represents the parasitic capacitance of the PCB layout. Figure 2b depicts the connections for the resistive measurement. This setup is intended for measuring platinum resistors (mode 5). Our tests have been performed with resistances $R_x = R_{ref} = 100\Omega$, while the biasing resistor $R_1 = 2.2k\Omega$. For both modes, the fast mode and the more accurate slow mode have been investigated.

Figure 3 shows the block diagram for the circuit board with a RS232 communication port. For this circuit a separate power source is needed to provide the supply voltage. This voltage is regulated to an analog voltage and a digital one. The microcontroller (μC) decodes the UTI signal and transfers it to a PC via a MAX232 chip.

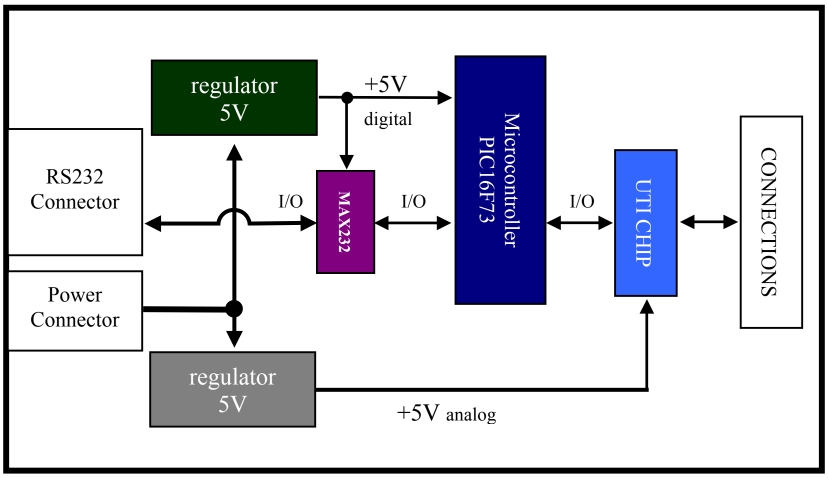

Fig. 3. Block diagram of the board with RS232 port.

Figure 4 shows a block diagram of the first evaluation board with a USB port. In this case, no additional power source is needed which makes it a simple solution. For data transfer to the computer a FT232BM chip is used.

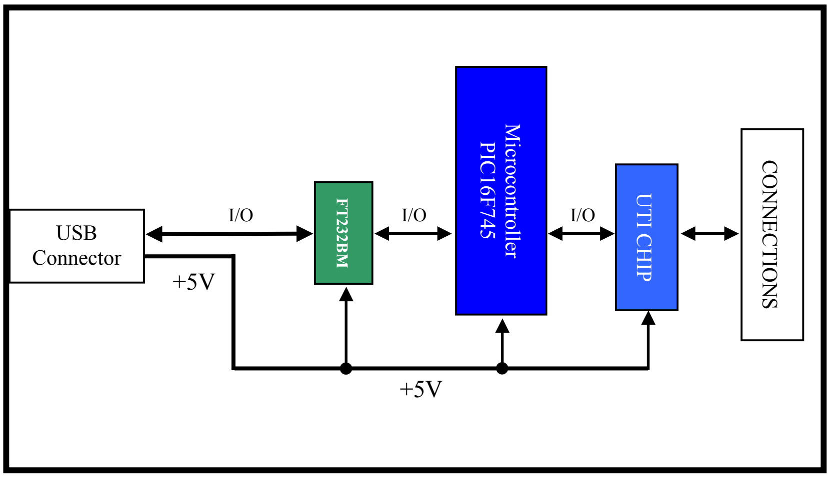

Fig. 4. Block diagram of a board with a USB port.

Figure 5 shows a block diagram of the board with improved USB features. In this circuit the power from the USB port is regulated by a low-noise charge-pump DC/DC converter (TPS60110) from Texas Instruments to have less noise on the power line of the circuit. The maximum amount of current that this DC/DC converter can deliver is 300mA with the fixed output voltage of +5V.

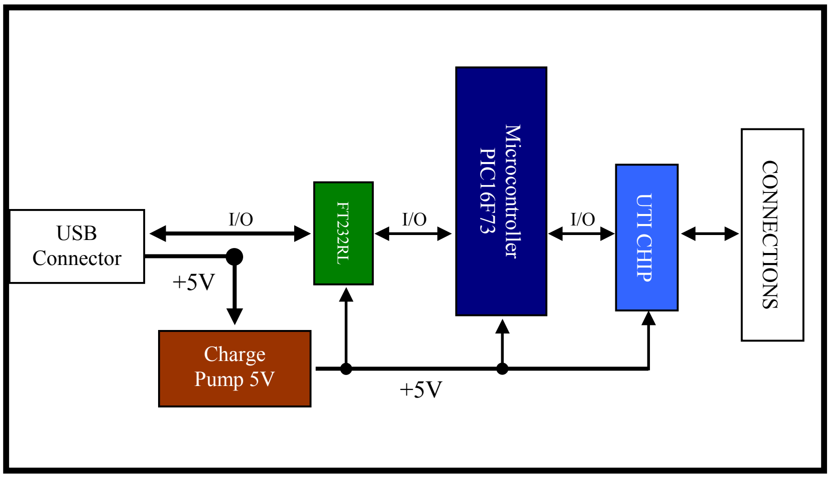

Fig. 5. Block diagram of the evaluation board that has a USB port for communication and a charge-pump DC/DC converter.

3. EXPERIMENTAL RESULTS AND DISCUSSIONS

Figure 6 shows the noise in the measured value of a stable capacitor with a nominal value of 1.8 pF. Table I lists the corresponding mean value, standard deviation and resolution in bit. From Fig. 6 and Table I we can conclude that, when we use the USB port as a power source, the noise that comes from it should be sufficiently suppressed. The USB evaluation boards with regulated low-noise charge-pump DC/DC converter allow a better noise suppression which, in the fast mode of the capacitive measurements, is two times better as compared to boards with a supply voltage that is directly delivered by the USB port. The mean values of the measured capacitances show some deviation with the nominal one. This is due to the tolerances of both the test capacitor and the reference capacitor and some influence of parasitic capacitances between the socket pins for the UTI. The measured supply current for the evaluation board with the DC/DC converter was 50mA for a supply voltage of +5V. With this DC/DC converter this evaluation board can work with supply voltages in the range of +2.7V to +5.4V.

The results for the resistive measurements are shown in Table II. Also in this case, the use of a low-noise charge-pump DC/DC converter reduces slightly the noise performance of the board.

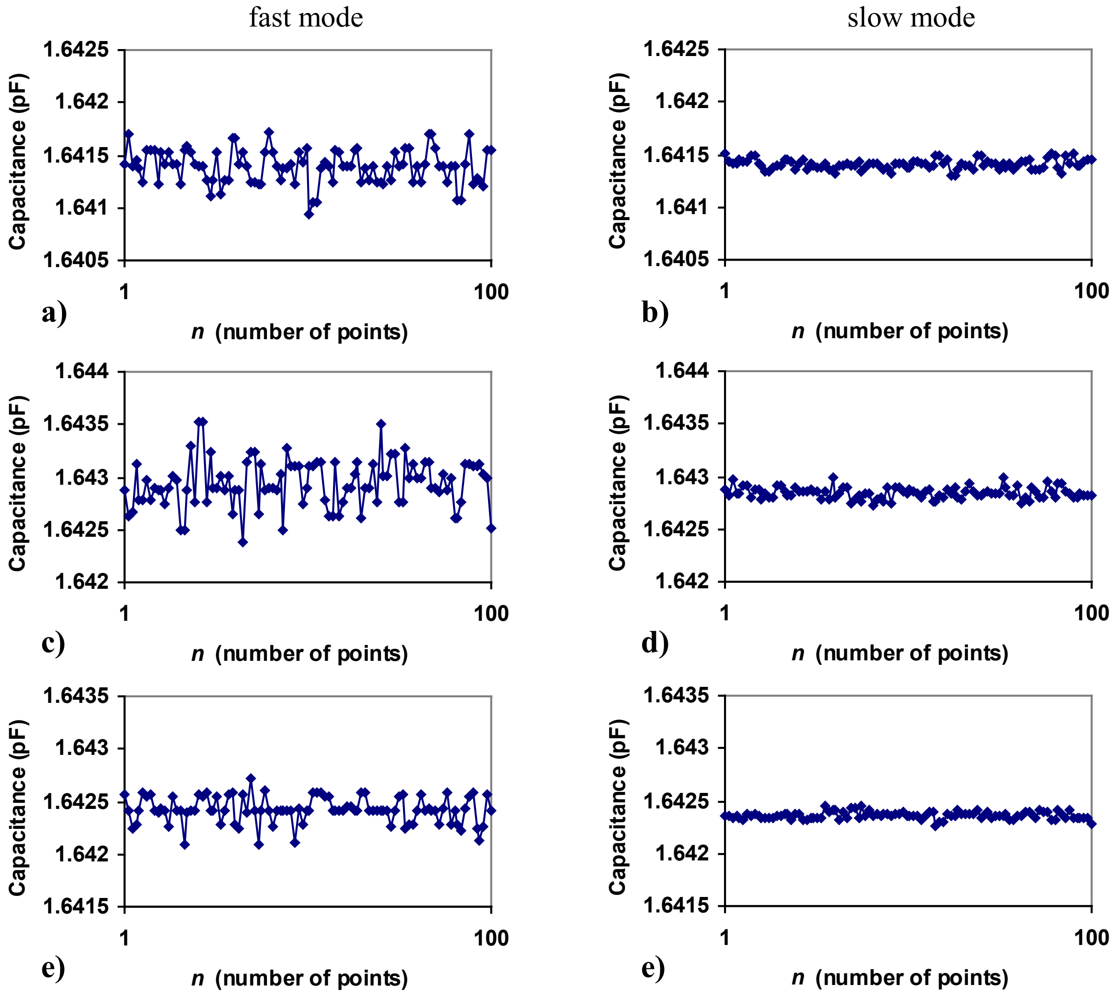

Fig. 6. Capacitive measurement results for the three evaluation boards.

Table I. Resolution of the three boards for capacitive measurements, for *n*=100 points.

Mode 1	fast mode			slow mode		
1.8 pF	mean (pF)	stdev (fF)	resolution	mean (pF)	stdev (fF)	resolution
RS232[1]	1.6414	0.16	13.3 bit	1.6414	0.04	15.6 bit
USB[2]	1.6429	0.23	13.1 bit	1.6428	0.05	15.2 bit
USB+CP[3]	1.6424	0.13	14.0 bit	1.6424	0.04	15.8 bit

Table II. Resolution of the three boards for resistive measurements, for *n*=100 points.

Mode 5	fast mode			slow mode		
100 Ω	mean (Ω)	stdev (mΩ)	resolution	mean (Ω)	stdev (mΩ)	resolution
RS232	100.094	13	12.9 bit	100.094	3.1	15.0 bit
USB	100.096	16	12.6 bit	100.086	3.7	14.7 bit
USB+CP	100.093	12	13.0 bit	100.094	2.8	15.1 bit

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[1] Circuit with RS232 port for communication.
[2] Circuit with USB port for communication.
[3] Circuit with USB port for communication and a charge-pump DC/DC converter.

4. CONCLUSIONS

It is convenient to use the USB port as a power source for small instruments and devices. However, for high-precision toolkits, such as the UTI evaluation boards, the noise from the DC voltage supplied by the USB port can degrades the noise performance of the board. It has been demonstrated that using a regulated low-noise charge-pump DC/DC converter, which regulates the power from the USB port, can solve this problem. As compared to existing solutions, the noise performance of the toolkit will increase with up to one bit. Moreover, because of the wide supply-voltage range of the power regulator, the proposed precision evaluation board can be used with the USB ports of any type of PC without loosing any accuracy.

ACKNOWLEDGEMENT

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5. REFERENCES

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