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Delta Encoder for Fiber Optic Based Data Transmission of Signals from Sensors

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Abstract – **In this paper are presented the results regarding the design and the implementation of a efficient delta encoder that is intended to be used for conditioning of signals from analogue sensors. In addition is proposed a dedicate circuit architecture for transmission of digitally encoded signals from sensors to remote measurement systems using a very reliable communication media that is represented by the optical fiber. The advantage of a reduced bit rate generated by the delta encoder correlated with the intrinsic advantages of the optical fibers, especially the immunity to electric perturbations, leaded to a attractive implementation solution for a conditioning interface that can be used in complex acquisition and measurement systems. Also, the proposed delta encoder and the fiber optic based transmission system can be used in didactical laboratories for teaching advanced communication techniques.**

Keywords - delta encoder; sensor; data transmission

I. INTRODUCTION

The conditioning of small amplitude signals from analog sensors for remotely transmission of measured information requires special design and high performances circuitry, especially when the location of the system is in the industrial environment characterized by high levels of electrical noise. In this context an approach based on signal processing for increasing the robustness and immunity of the sensor's signals to external electrical perturbations is desirable. In our implementation we chouse to convert the signals generated by input sensor into a digital format, using a linear delta modulator and to transmit remotely the encoded signal using a bidirectional fiber optical module which proved it's reliability in harsh industrial environments characterized by high levels of spurious signals. The range of applications for the proposed design is very wide, the architecture described in this paper been applicable to any type of measurement and acquisition system that must operate with remote sensors placed in noisy environments [1], [2].

II. THE PRINCIPLE OF DELTA ENCODING

Delta encoding represents an efficient technique for digitizing analog signals. It is characterized by the fact that in one sampling interval only one binary symbol is generated to the output of the encoder. The delta encoding is a predictive technique that is based on the reduction of the redundancy of successive samples and encoding only the newer information (the difference between consecutive samples). In Fig. 1 is presented the principle of a linear delta encoder/decoder. As can be observed from this figure, the continuous input signal, $u_{m1}(t)$, is band-pass filtered and from resulted signal, $u_m(t)$, is subtracted an recovered signal, $\hat{u}_m(t)$, in this way resulting the error. At the end of the encoding process will result a sequence of digital pulses which contain the useful information. Also, by integrating continuously the output signal, an approximation of the input waveform is generated and is used for error calculation [3].

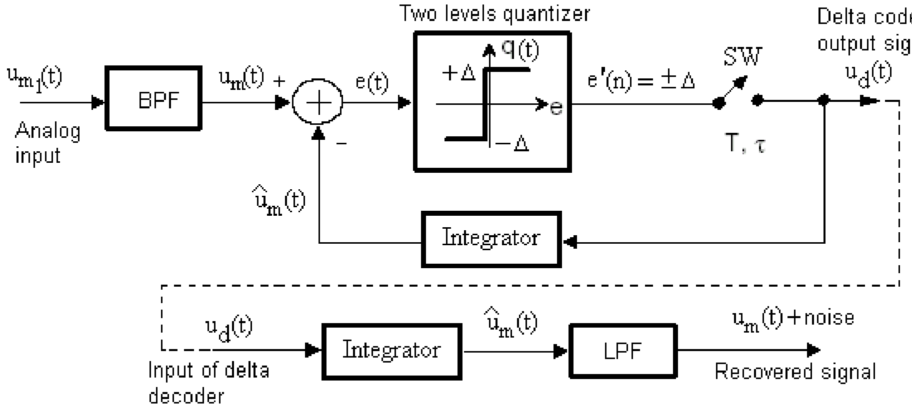

Figure 1. The principle of a linear delta encoder/decoder.

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The most important parameters of the linear delta encoder are represented by the quantization step (Δ) and the sampling frequency (f_e). Especially the quantization step must be carefully adjusted taking into consideration two contradictory requirements that impose a compromise between the quantization error and slope overload.

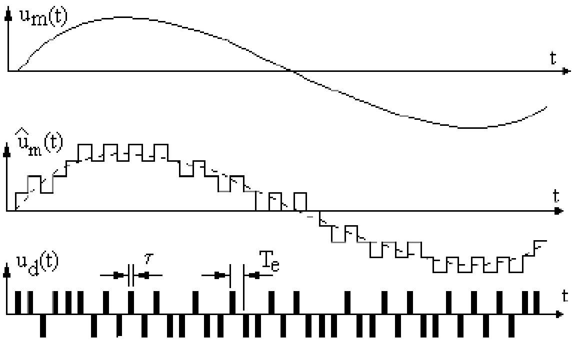

Figure 2. Representative waveforms for an linear delta encoder: the input signal, $u_m(t)$, the approximated signal, $\hat{u}_m(t)$ and the output signal $u_d(t)$.

As can be observed from Fig. 3 and Fig. 4, by chousing a smaller quantization step it is reduced the quantization error but appears the slope overload of delta encoder. Conversely, if is used an too large quantization step for compensate slope overload will result a high quantization error of delta encoder due to improper choosing of quantization step [4].

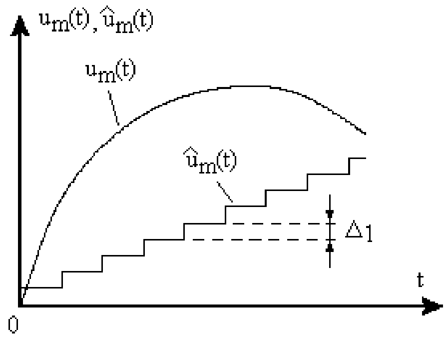

Figure 3. Slope overload of delta encoder generated by a smaller quantization step.

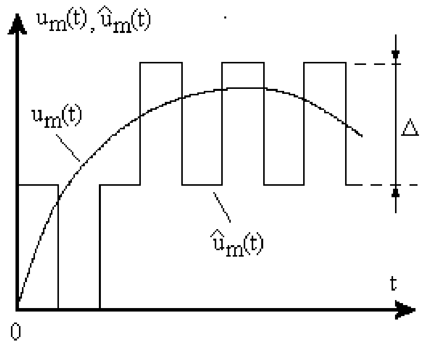

Figure 4. High quantization error of delta encoder due to improper choosing of quantization step which in this case is too large.

III. THE IMPLEMENTATION OF THE SYSTEM AND THE OBTAINED RESULTS

In the implementation proposed in this paper, for transmission of delta encoded signals acquired from the analog sensor, a bidirectional optical module was used (Fig. 5). A pair of two such optical modules are necessary for establish a bidirectional communication between two measurement systems.

The transmitting and receiving modules used in the implementation are HFBR 1521Z and HFBR 2521Z respectively. These modules require a 5V supply source and are compatible with TTL circuits (transistor-transistor-logic). The maximum achievable communication distances using a standard multimode RLS001Z optical fiber is of approximately 120m. Due to cost constrains the transfer rate performances obtained with the respective Tx/Rx modules is around 40 kB/s but this parameter can be dramatically improved by using more performing transmitters, receivers and an low attenuation optical fiber.

The data transferred on the optical fibers can be supplementary encoded with a simple line code RZ (return-to-zero), for improved clock recovery at the receiver side. The rest of the blocks contained in the optical module diagram presented in Fig. 5 are necessary for proper conditioning of the signals. In addition, the module has the capability to realize a bidirectional communication between to computers, using serial interface, RS 232.

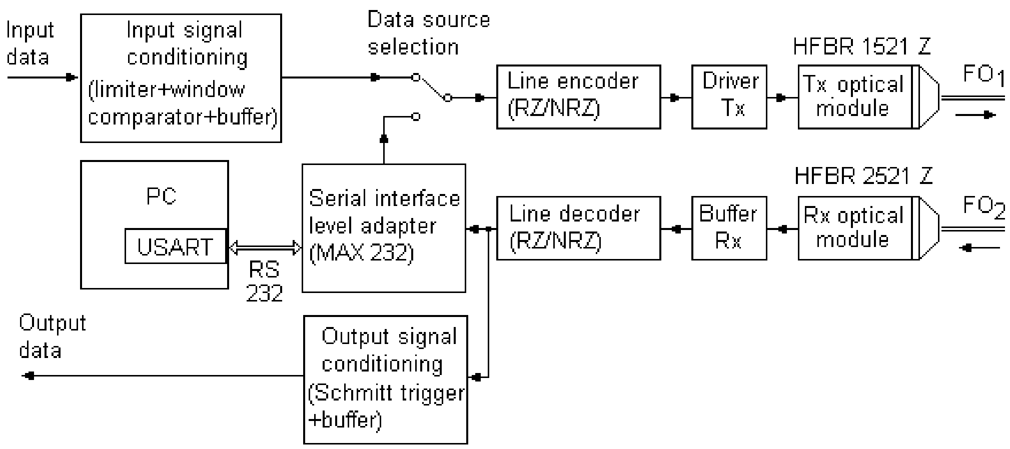

Figure 5. The block diagram of the optical module used for transmission of delta encoded signals.

The simplified electrical diagram of the delta encoder used for transmission of signals from sensors using fiber optics is presented in Fig. 6. In the structure of the simulating model can be remarked a set of variable gain input amplifiers that besides the amplification allows also realizing an offset adjustment of the analog input signal received from the sensor. This scalable adjustment is necessary in case of operation with various types of sensors, characterized by a wide range of electrical specification for the output signal. After conditioning, the signal is applied directly to the comparator realized with an TL 082 operational amplifier. This type of circuit was chose because of its relatively high operation speed and high input impedance which was satisfactory for the proposed application. The feedback integrator for approximated signal generation is also implemented with this kind of operational amplifier. In the simplified version of the delta encoder we worked with fixed quantization step and sampling frequency. An 74HC74 flip-flop was used for final forming of the impulse train that represent the linear delta modulated signal. In case of operation with high speed analog signals, an adaptive structure of circuit, based on continuously variable slope delta modulator must be use in order to obtain good results. In our approach we considered slow variation signals, with a maximum 10 KHz frequency, coming from sensors that measure physical parameters characterized by slow variation in time, such is temperature [5].

The correct operation of the proposed design was verified through extensive simulations and practical experiments.

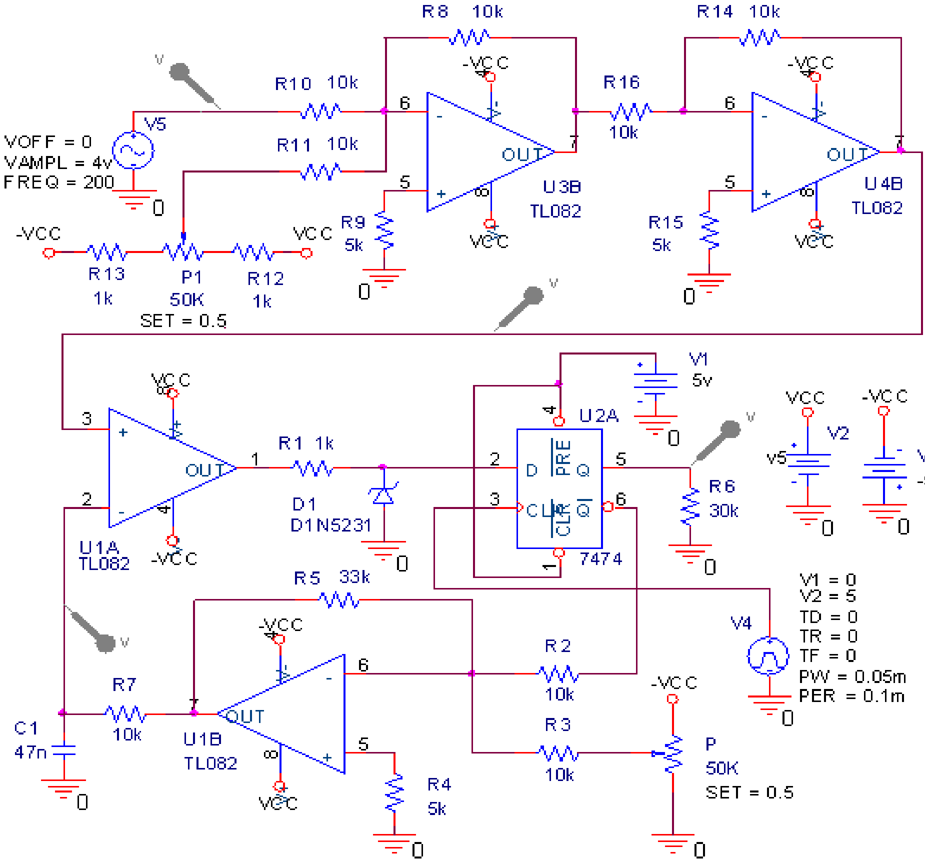

Figure 6. Simplified model for simulating the operation of delta encoder used for transmission of signals from sensors using fiber optics

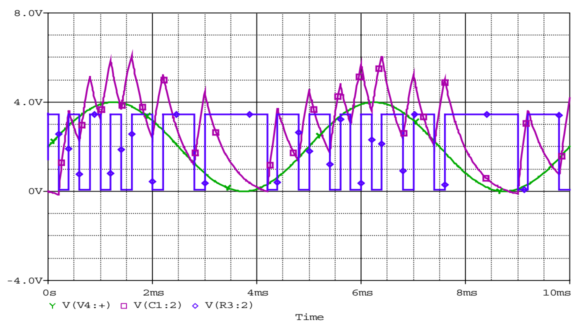

Figure 7. Simulated waveforms visualized in the representative points of the delta encoder considering that integrator has the $C_1 = 47\mu F$.

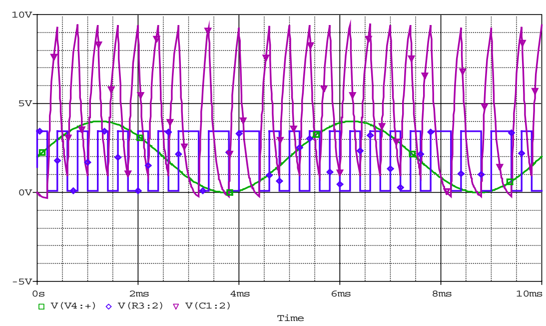

Figure 8. Waveforms resulted when delta encoder operate with an integrator having the reaction capacitor $C_1 = 10\mu F$.

In the Fig. 9 is depicted the prototype board with the electrical circuit of the linear delta encoder used for tests. The printed circuit of the encoder is realized in a didactical manner, with multiple test points for facile investigation of the circuit's operation. Also, in Fig. 10, is presented the experimental setup used for implementing the data transmission with delta encoded signals, using a pair of multimode optical fiber. This set of two bidirectional modules can realize tow type of functions. In the first mode of operation the optical modules can ensure the communication interface between an analog sensor and the PC, for transferring the measured data in digital format using delta encoding. In the second mode of operation, both module are connected to PCs and transfer digital data between them using serial format.

Figure 9. The prototype board of the delta encoder.

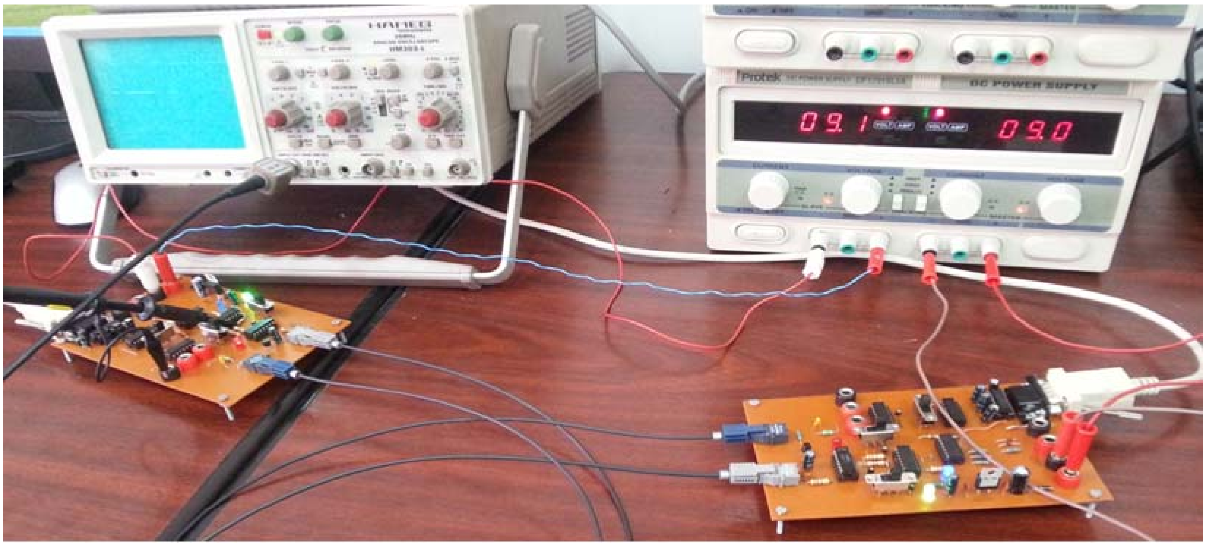

Figure 10. The experimental setup for testing the transmission of delta encoded signals using a pair of multimode optical fibers.

IV. Conclusions

Delta encoding has the advantage of a reduced bit rate at the output compared with other similar techniques. By combining this advantage with the intrinsic immunity of the optical fibers to electric perturbations and noises we obtain an attractive implementation solution for a conditioning interface that can be used in measurement and acquisition systems that operates in harsh industrial environments.

The proposed design for the delta encoder and of the optical modules is also suitable for didactical purposes, in teaching signal processing techniques and advanced digital communication techniques.

The performances parameters of the proposed system can be further improved by using more performing optical transmitters and receivers combined with optical fibers having a reduced attenuation.

References

[1] Fabio Gomez-Estern, Carlos Canudas-de-Wit ; Francisco R. Rubio ; Jose Fornes, "Adaptive Delta-modulation Coding for Networked Controlled Systems", American Control Conference, pp. 4911 – 4916, 2007

[2] Yan Mi, Shaoqin Rui, Shoulong Dong, Chenguo Yao, Chengxiang Li, Zhongyong Zhao, "Optical fibersensor system for monitoring leakage current of post insulators based on RBF neural network", International Conference on High Voltage Engineering and Application (ICHVE), pp. 1-4, 2014

[3] Hao Zheng, Zhongda Lu, "Research and design of a 2-Bit Delta Modulator encoder/decoder", 24th Chinese Control and Decision Conference (CCDC), pp. 3586 – 3589, 2012.

[4] Andrei Drumea, Cristina Ioana Marghescu, "Analysis of current carrying capacity of silver-based conductive pastes for PCB repair", 21st International Symposium for Design and Technology in Electronic Packaging SIITME2015, pp. 297-300, October 2015.

[5] En-hui Yang, Da-ke He, "Near lossless source coding with side information at the decoder: Beyond conditional entropy", Information Theory and Applications Workshop, pp. 454 – 460, 2008.