Increasing the efficiency of absorption-resorption heat pumps in conditions of energy saving

Oleksandr Shostak
Pervomaisk Educational and Scientific Institute of Admiral Makarov national university of shipbuilding.

Abstract. Some methods of increasing the energy efficiency of heat supply in modern conditions in the residential communal economy are analyzed.

Thus, the introduction of such innovative implementations in heat supply systems as thermomizers for automatic regulation of hot water temperature in heat supply systems and heat carrier temperature in heating systems, heat pumps and air heat recovery systems increase the energy efficiency of heat supply in modern energy saving conditions.

Technical and economic calculations show that these innovations can reduce energy costs by at least 40...60%.

Keywords: heat supply, heat pump, thermomizer, recuperation, coolant, heat exchanger.

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BASELINE CORRECTION TECHNIQUE FOR POLYMETRIC SIGNAL INTERPRETATION

Gudyma E.A.[1]
Graduate student, i.gudyma@digitalamico.com
Zivenko O.V. [1]
Associate Professor, PhD., oleksii.zivenko@nuos.edu.ua
Zhukov Yu.D.[1]
Full Professor, DSc. yuriy.zhukov@nous.edu.ua
1 – Maritime Instrumentation Department, Admiral Makarov National University of Shipbuilding, Mykolaiv, Ukraine

Abstract. The uncertainty in the level measurement by polymetric systems was examined, focusing on the impact of baseline estimation techniques. A polynomial baseline model observed notable improvements in nonlinearity compared to the conventional method. The findings highlight baseline stability evaluation, baseline robustness study, and algorithm optimization as key research areas, especially for efficient real-time processing on constrained hardware.

Keywords: baseline, correction, polymetric systems, signal processing.

Introduction. It’s common in signal processing to use a reference level of the signal for feature calculation (also called baseline, “zero-level” or “zero-line”). This baseline provides a reference point used to compare different signals and analyze changes in a signal over time. Establishing a common baseline makes it easier to identify patterns, trends, and anomalies. This is especially useful when trying to identify peaks or slow-shifting anomalies in signals that are exposed to noise or interference, as is the case with polymetric systems [1-3]. For these systems to be effective in industrial contexts, one must address challenges posed by background noise and significant baseline drift.

There are various approaches to baseline definition and estimation that depend on signal type and particular goal (one level, or a complex curve) in the context of application. This review focuses on the techniques and definitions employed to estimate the "zero-level" models predominantly in the context of polymetric system signals used for accurate level and temperature measurements [3,4]. There are different possible interpretations of what exactly a “baseline” is. At [5-8], the authors provide a review of the primary methods for defining and estimating baselines and baseline correction techniques for various signal types. Assuming the signal is entirely positive, rising from a theoretical zero baseline, a smoothed running minimum can serve as a suitable baseline. On the other hand, if the noise is expected to vary around a baseline, as seen in cases with independent and identically distributed (iid) normal fluctuations, then a central measure like the median or mean would be more fitting.

Objective. The work is focused mainly on the baseline estimation and correction technique aiming to reduce the influence of the zero-line drift and improve the overall accuracy of the polymetric system.

Main material. The importance of baseline estimation can be explained using Figure 1, where the simplified approach of time delay estimation between 2 peaks is shown.

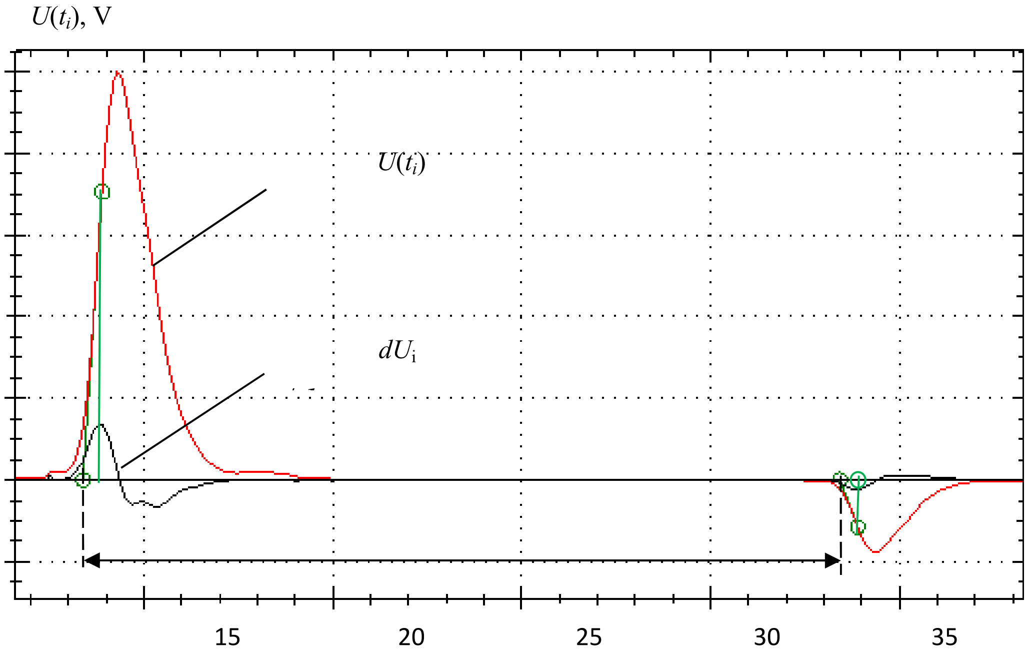

Figure 1 – Simplified explanation of time delay estimation and baseline influence

This signal $U(t)$ is a typical representation of a waveform used for distance estimation in level sensors using the measurement of time T – the time between moments of the sounding and receiving of the characteristic pulses. Voltage U is measured at the discrete moments of time t_i, where i stands for sample number. The time discretization step Δt_i is controlled by the hardware.

In early-generation polymetric systems, the threshold technique was used for peak detection and time-delay estimation (simply picking pulses above some level set). This simple approach gives acceptable results in applications with medium levels of precision because it's very sensitive to any signal drift. To overcome the issue with relatively small zero-line drifts, derivative-based techniques were implemented (in the specified example, the derivative technique is visualized). The derivative of a signal is calculated, and the points with the maximum derivative values are selected as peaks-coordinates. When dealing with real-world applications, several additional processing steps are made (like signal filtration to reduce the noise power, averaging to minimize the influence of random fluctuations, etc.). An important moment worth mentioning is signal distortion due to the propagation of the electromagnetic wave and the dissipation of energy in the liquid (energy loss). That causes the waveform change of the reflected pulse depending on the distance where reflection happens, which causes a problem in estimating the time delay T because the waveform was changed compared to the signal emitted. In this case, a model-based approach is used, where some approximation of a waveform is used for estimation of the specific pulse point position. In the case of a Gaussian-type sounding pulse, the tangent to the graph of the function $U(t)$ at the point where the time derivative of this function has an extremum – t_A (point A for the sounding pulse and A' for the reflected pulse). Those points approximate a rising edge with some model, e.g., a straight line or a spline. The coordinates of the start points for the sounding and reflected pulses (points t_s, t_r on Fig. 1) are calculated as the intersection points of the baseline and approximated lines.

Simplified baseline calculation is performed using a selected portion of the initial waveform - a part of a signal before the sounding pulse. The manufacturer/user specifies a region based on parameters estimated during a production process or specific application. In this case, the baseline is assumed to be a constant value over the time-axis while still recalculating each run as a simple mean/median value for the part of the signal. This approach works significantly better than simple thresholds for peak time delay measurement because it's less sensitive to the baseline drift. However, in case of signal distortions in the preselected area, baseline calculation is biased, which leads to the error in pulse start point estimation. To overcome this issue, 2 approaches were tested: the assumption of the constant-value baseline model and the assumption of the polynomial baseline model (for 2 cases: both for all data given and for data with pulses regions excluded). The optimization technique was used to estimate the baseline parameters similarly to approaches in [5, 7]. The model used to estimate the baseline included the data on the voltage measurement uncertainty based on the data provided by the ADC manufacturer.

Results and Discussion. The mean & maximum absolute values of nonlinearity of the level measurement channel were compared for all cases. It's crucial to emphasize that our research focuses solely on the nonlinearity component in the total channel measurement uncertainty (other uncertainty sources or interference were not accounted for). For our analysis, we estimated a polynomial baseline model, excluding pulse regions from the data. When compared to the traditional method (which derives a constant baseline value based on a predefined signal region), the mean nonlinearity value dropped from 0.97 mm to 0.67 mm. Concurrently, the maximum nonlinearity value declined from 5.6 mm to 3.01 mm. This was assessed over 14 sensor-length points for a maximum uncertainty in distance estimation allowed of ±0.15 mm.

Looking forward, it's necessary to assess the resilience and robustness of this technique against varying interference levels. The baseline might fluctuate over time due to factors like temperature changes or material buildup on the sensor. Therefore, studying baseline stability and tracking is essential. Moreover, understanding the nature of baseline shifts and related signal changes could enhance accuracy or aid in detecting equipment malfunctions and predictive maintenance of the control system.

The proposed method for baseline estimation and subsequent corrections notably enhanced the linearity of the level measurement channel. Future research should investigate baseline model evaluation concerning sensor hardware specifics, like its probe profile, etc. Such insights could speed up and optimize baseline estimation, potentially reducing computational demands. This would pave the way for efficient real-time scale processing, even on constrained hardware with small resources to solve optimization tasks.

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МЕТОД КОРЕКЦІЇ БАЗОВОЇ ЛІНІЇ ДЛЯ ІНТЕРПРЕТАЦІЇ ПОЛІМЕТРИЧНОГО СИГНАЛУ

Гудима Є.А.1
Студент, i.gudyma@digitalamico.com
Зівенко О.В.1
Доцент, кандидат технічних наук, oleksii.zivenko@nuos.edu.ua
Жуков Ю.Д.1
Професор, доктор технічних наук, yuriy.zhukov@nous.edu.ua
1 - Кафедра морського приладобудування, Національний університет кораблебудування імені Адмірала Макарова, Миколаїв, Україна

Анотація. Досліджено вплив базової лінії на невизначеність вимірювання рівня поліметричною системою. Використання поліноміальної моделі базової лінії дозволило значно поліпшити показники нелінійності вимірювального каналу порівняно з традиційним методом. Перспективним напрямком подальшого дослідження є вивчення стабільності та стійкості методу до завад та впливів, оптимізація алгоритмів оцінки/корекції базової лінії для ефективної обробки із використанням обмежених обчислювальних ресурсів.

Ключові слова: базова лінія, корекція, поліметричні системи, обробка сигналів.

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ПРОБЛЕМА УЗАГАЛЬНЕННЯ СПЕКТРІВ ТРИВАЛИХ НЕСТАЦІОНАРНИХ СИГНАЛІВ

Касьянов Ю.І.
старший викладач кафедри комп'ютерних технологій
та інформаційної безпеки
Національного університету кораблебудування імені адмірала Макарова
м. Миколаїв, Україна
yukas.nik.ua@gmail.com

Анотація: Розглянуто проблему узагальнення спектрів тривалих нестаціонарних сигналів та визначено можливі шляхи її вирішення. Наведено приклад узагальнення спектрів довготривалих українських мовленнєвих сигналів, отриманих в програмі Sound Forge, шляхом обробки зображень в Mathcad.