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SELECTED PROBLEMS OF WIRELESS TRANSMISSION OF MEASUREMENT SIGNALS

The article presents the quantified and qualitative effects of the application of wireless signal transmission with particular emphasis on the effects of repeated signal transformation and synchronization problems when using more complex measurement systems containing parallel operating wired and wireless interfaces.

INTRODUCTION

Wireless transmission of measuring (and control) signals is necessary everywhere where there is a need for data transmission over long distances, lack of access (or poor access) caused, for example, by the application of elements of the measurement system on a quickly rotating element. Wireless transmission is also useful wherever wiring requires the use of cumbersome shields or compensating for the varying length of cables mounted on multipart manipulators or booms of working machines.

Wireless data transmission in such applications (with a limited range, e.g. up to 10 m or 100 m) is carried out primarily by radio waves of high frequency in bands, which in many countries are made available for use without permission (so-called ISM band). The required mobility of components of the examined objects excludes the use of infrared communication [1] Transmission of measurement data by radio is, however, associated with a number of factors, which call for a special attention: coverage (limited not only by the distance of the transmitter and receiver but also by the presence of obstacles), data transmission rate and the presence of distortions.

1. MODIFIED MEASURING SYSTEM OF THE OVERHEAD TRAVELLING CRANE

Laboratory of the Department of Off-Road Machine and Vehicle Engineering (Wroclaw University of Science and Technology) is equipped with a lightweight overhead travelling crane. It is (next to the standard in this group drive and control system) equipped with a measuring system that allows identification of selected crane loads. For this purpose, during the installation, wiring was installed on the crane (so-called cable sheaths) enabling, in addition to power supply, a wired acquisition of measurement signals from strain gauges measuring lateral forces [2, 3]. For the needs of the implementation of a wider research program, the existing measuring system has been expanded by measuring transducers enabling the acquisition of measurement signals from the sensors of the travelling speed of

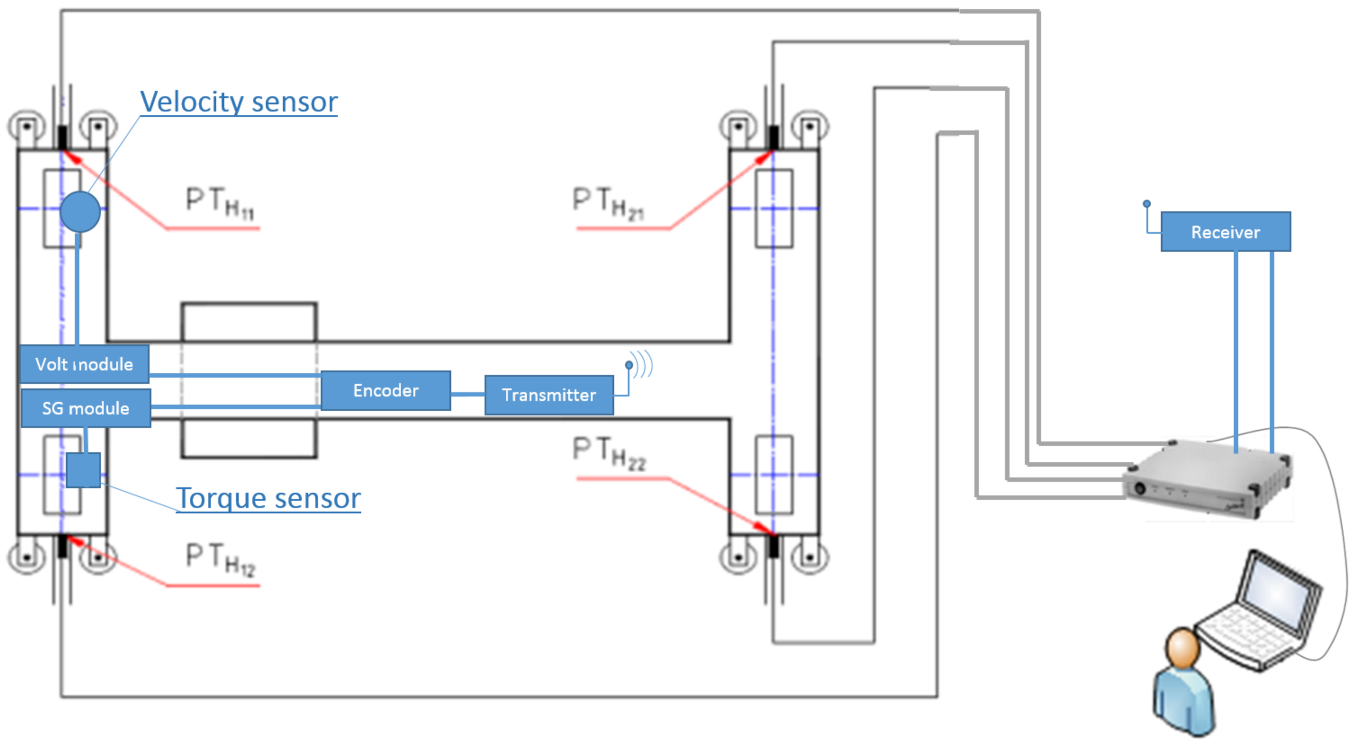

Fig. 1. *Scheme of an extensive measurement system of the overhead travelling crane (PT-strain gage sensor of lateral forces)*

the crane and the torque of the gearmotors. Due to the lack of a sufficient number of wired lines, it was decided to use an additional subsystem enabling wireless transmission of signals. A modular system for wireless transmission of measurement signals from KMT was used for this purpose. The extensive measuring system is shown in figure 1.

It should be noted that due to the purpose of the measurements, it was important to be able to acquire all measurement signals using one amplifier (Spider8 from HBM [4]) operated using one measurement application (Catman from HBM [4]) outside the crane. Such integration was possible due to the fact that the outputs of the telemetry subsystem are analogue +/- 5V standard signals supported by the Spider8 measuring amplifier.

1.1. Description of the modular telemetric measuring system

A modular system for transmission of measurement data by radio was used for the tests. This system, developed by Kraus Messtechnik GmbH [5], works in the IMS radio band (433 MHz) and enables wireless transmission over a distance of 10 m (and more in the absence of obstacles). Like every system of this type, it consists of the following components (figure 2):

- data acquisition modules,
- PCM Encoder, multiplexer and controller,
- transmitter (HF) - 1280 kbit/s,
- transmitter antenna,
- power supply module (battery or accumulator),
- terminator,
- receiver antenna,
- receiver station with decoder and 8 channel analog out +/-5V (BNC connectors).

Basic technical parameters: frequency response (according to the manufacturer): 3 kHz, 5V supply, possible acquisition of signals from 8 measuring channels.

2. SYNCHRONIZATION OF THE TELEMETRIC MEASURING SUBSYSTEM WITH THE EXISTING WIRED MEASURING SYSTEM

The problem of synchronization during transmission of measurement data concerns each measuring system consisting of a larger number of components [6, 7]. Particular attention should be paid to this issue when acquiring fast-changing signals and for long-term measurements. Professional measuring equipment usually contains tools for synchronization (e.g.: dedicated synchronizing channel or bus). When such a tool is not available, it is necessary to assess the possibility of using non-synchronized elements of the measurement system without damaging the metrological correctness of the research process.

The structure of the telemetry system and its specific implementation causes that the measurement signals are repeatedly processed: conditioning, anti-aliasing filtering, A/C processing (sensor module), digital multiplexing (encoder, with PCM output), FM modulation (transmitter), demodulation and C/A processing with smoothing filter (receiver).

All these operations cause the delay of signals transmitted by radio. In this case, it is necessary to identify delays in order to correctly analyze and interpret the obtained measurement results.

2.1. Identification of delays in the wireless part of the measuring system

A simple measuring system was built (figure 3) to identify the delays. The generated triangular signal was fed in parallel to both inputs of the digital oscilloscope. The first channel received the signal directly from the generator, the second channel received the same signal from the generator, but transmitted via a modular telemetry system. An example of the result in the examined frequency band (up to 1 kHz) is shown in figure 4. From the user's point of view, it is important that the measured delay has a constant value. In the tested frequency range, different delays were obtained depending on the frequency. For example, 0.42 ms at frequency of 800 Hz (fig. 4) and 0.43 ms at frequencies of 400 Hz and 500 Hz (fig. 4). This difference makes it difficult to introduce corrections (delays) in the recorded waveforms of measurement signals during data the analysis.

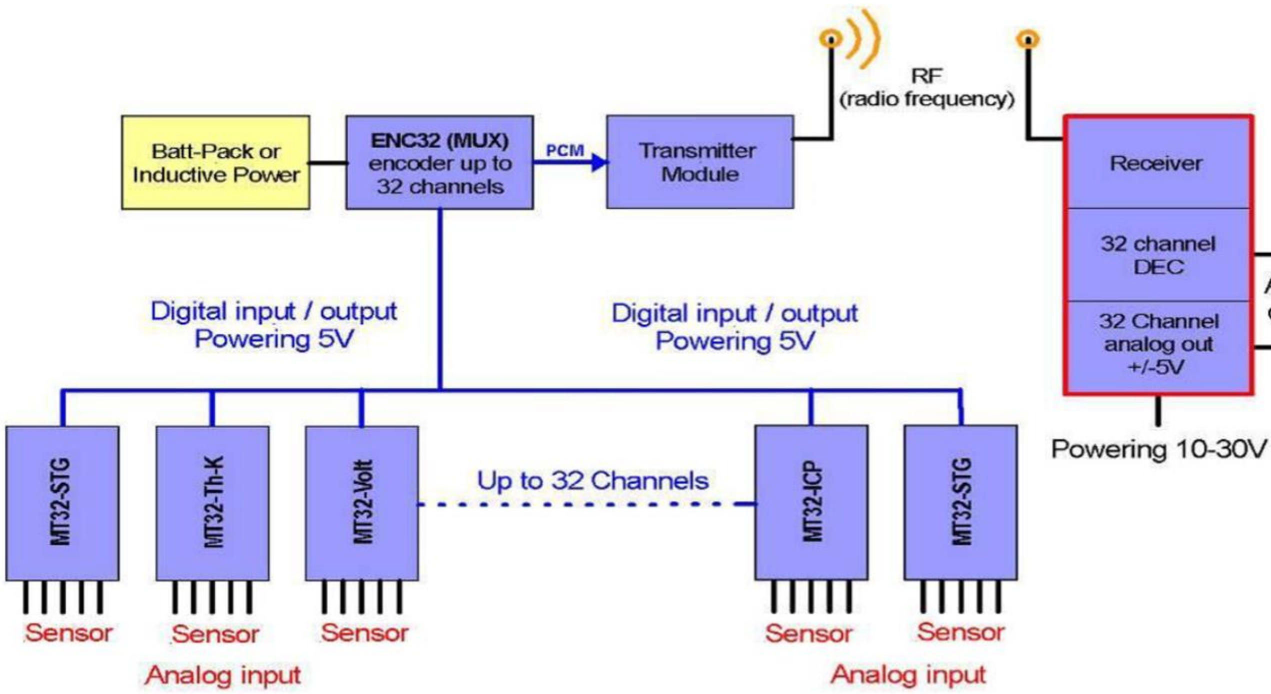

Fig. 2. Components of the modular transmission system [5]

3. IDENTIFICATION OF DISTORTION OF MEASUREMENT SIGNALS

Multiple signal processing (filtering, modulation and demodulation) is also a source of significant modifications of recorded signals. figure 5 shows the form of signals transmitted by radio in comparison with wired signals at different frequencies of transmitted signals (200 and 800 Hz). The same measuring system was used here (figure 3). The waveform of the signal shows that the filtration has the greatest influence on the modification: anti-aliasing filter and smoothing filter).

Observed signal changes are important because they cause, like any filtration, amplitude modifications and phase shifts. When analyzing the measurement results, it should also be taken into account that the Spider 8 measuring amplifier is also equipped with a low-pass filter (Bessel), whose parameters can be set in a programmatic way so that its influence can be easily identified. The conducted identification concerned relatively small frequencies (up to about 1 kHz), which in the case of some mechanical interactions is a sufficient value. Due to the limited frequency response resulting from the anti-aliasing filters used, this system cannot be used to identify dynamic loads in the wider frequency range.

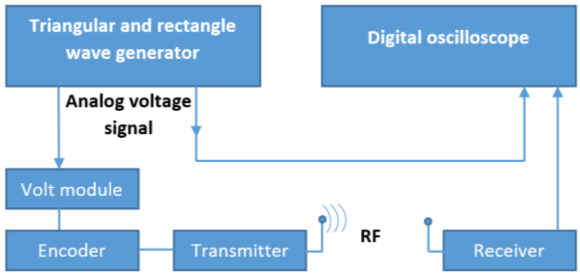

Fig. 3. A measuring system for evaluating the delays of a wireless subsystem

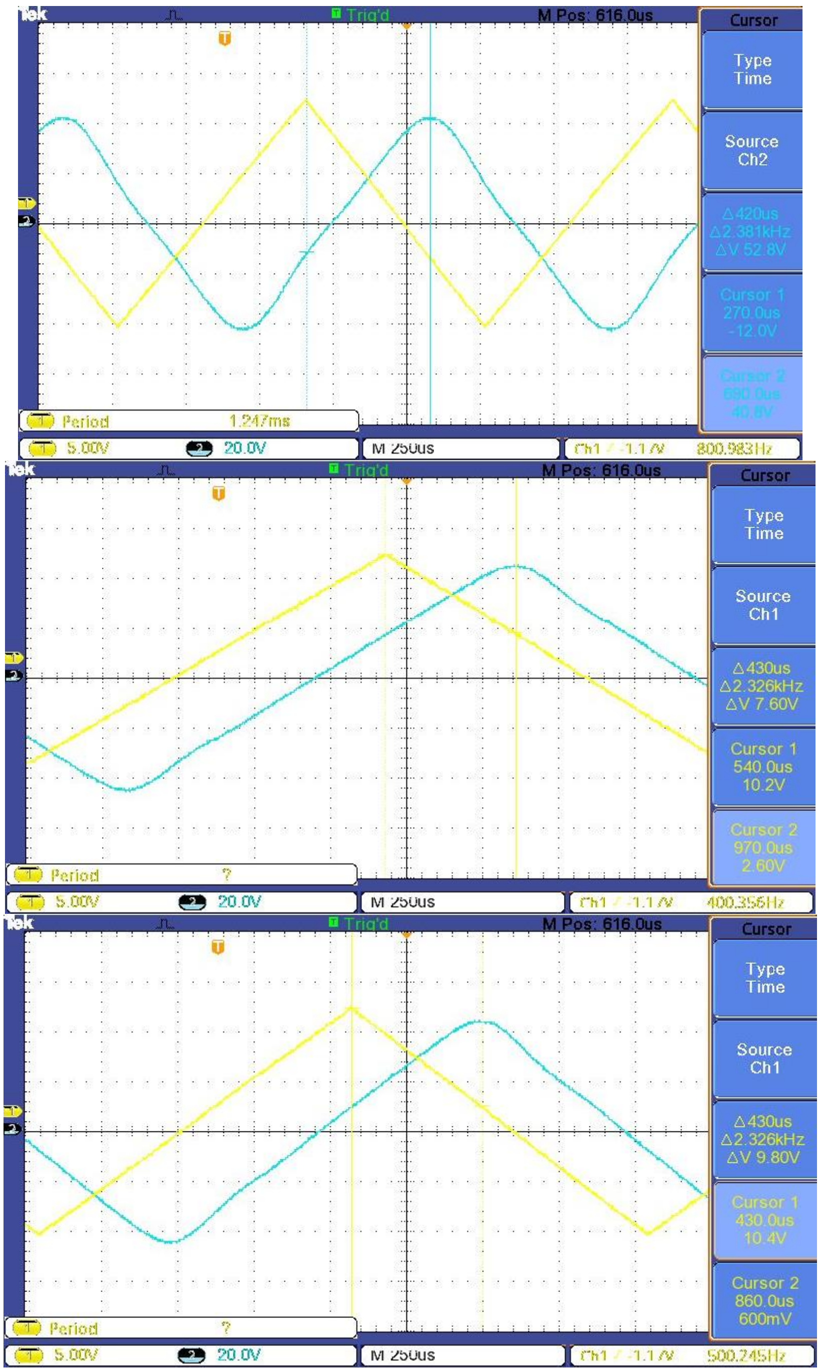

Fig. 4. Delays in the wireless part of the measuring system-in blue and triangular wave signal (800, 400, 500 Hz) from generator-in yellow

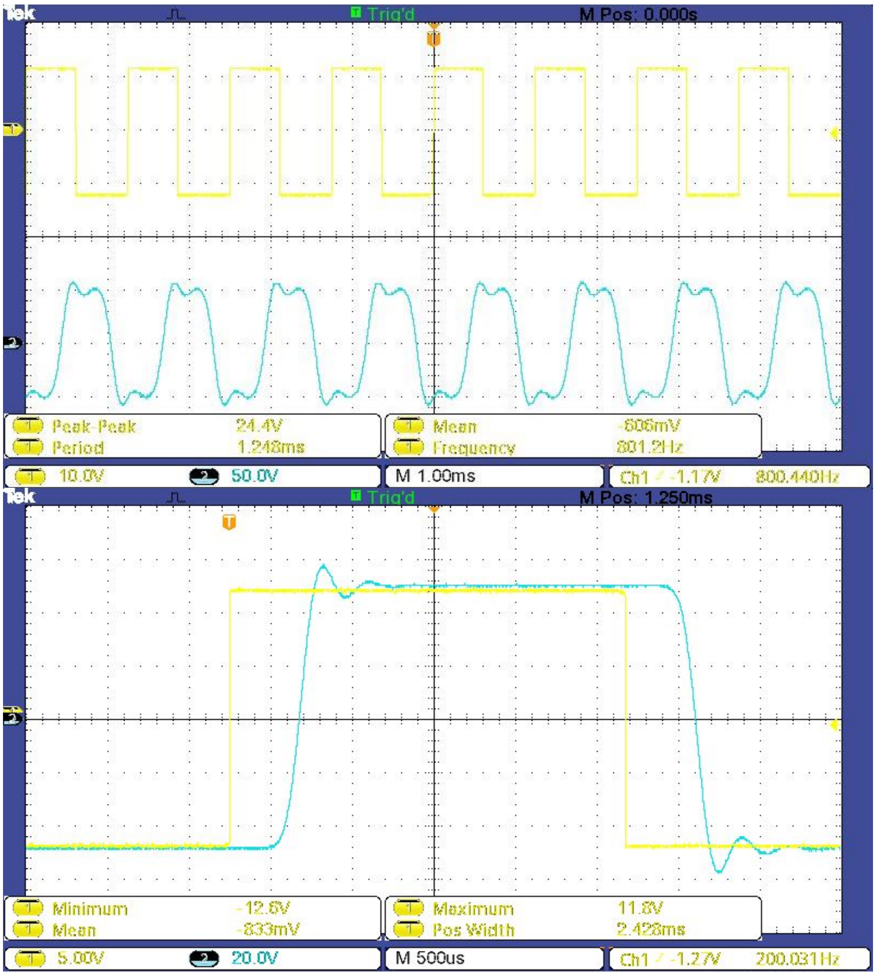

Fig. 5. *Distortion of measurement signals-in blue and rectangular wave signal (800 and 200 Hz) from generator – in yellow*

CONCLUSIONS

Wireless transmission of measurement signals is a very convenient way to avoid cumbersome wiring. The use of this method, however, involves the need to take into account the specificity of the transmission method and the consequences resulting from it: signal modulation and its delay. Obtained results of measurements indicate the need for time synchronization of measurement signals in more complex structures composed of subsystems using various methods of transmission of measurement signals.

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Wybrane problemy bezprzewodowej transmisji sygnałów pomiarowych

W artykule przedstawiono zidentyfikowane ilościowo i jakościowo efekty zastosowania bezprzewodowej transmisji sygnałów ze szczególnym uwzględnieniem skutków wielokrotnego przekształcania sygnału a także problemów synchronizacji w przypadku stosowania bardziej złożonych układów pomiarowych zawierających równolegle działające interfejsy przewodowe i bezprzewodowe.

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