LABORATORY STAND FOR INERTIAL SENSOR TESTING AND VERIFICATION

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In this paper the laboratory stand for IMU testing and verification is described. Sample test results of selected IMU properties, collected during dynamic verification of linear acceleration and angular rate sensors, are presented.

Keywords: metrology, laboratory test stand, integrated measurement unit (IMU), inertial sensor

Nowadays, the integrated measurement units (IMU) are widely used for the inertial measurement of linear acceleration and angular rate. The typical IMU sensor usually contains 3 accelerometers and 3 gyroscopes, what permits a 6-degrees-of-freedom measurement. Advantages of accelerometers and gyroscopes manufactured with MEMS (micro-electro-mechanical-systems) technology include small dimensions and weight, high resistance to impact and other mechanical damages, wide range of working temperature and low power consumption. It causes that MEMS sensors are commonly used as elements of measurement systems with special operational requirements [1-3]. However, some technical problems are fully revealed at the stage of practical implementation of proposed system. In particular, the choice of sensors in terms of compliance with design requirements (i.e. accuracy, stability, bandwidth, sampling and recording frequencies, communication interfaces, etc.) is crucial for the success of the whole project.

From the foregoing it will be seen that the tools for IMU verification are strongly required. The objective of this article is to present an authorial solution for inertial sensor testing.

Block scheme of the proposed laboratory stand is shown in Fig. 1. It includes: rotary table with microprocessor control unit, communication module with socket for embedding a sensor under test, two PC with dedicated software and the wire set. Test stand equipment and specialized software allow to perform both static tests (i.e. to determine the noise level) and dynamic tests (for accuracy and stability evaluation) of considered IMUs.

Rotary table drives enable a high-precision rotation of measurement platform horizontally (without limitation) and vertically (in the range of ±90°) with the maximum angular rate of 60°/sec. Table driver software communicates with a microprocessor control unit via RS-232 and PELCO-D protocol. It provides several built-in test programs, including, among others, multiple rotation of tested sensor both with respect to the axis of reference coordinate system and with random courses, with fixed and variable angular rates in the range of 5 to 60°/sec. User-defined test programs are also available.

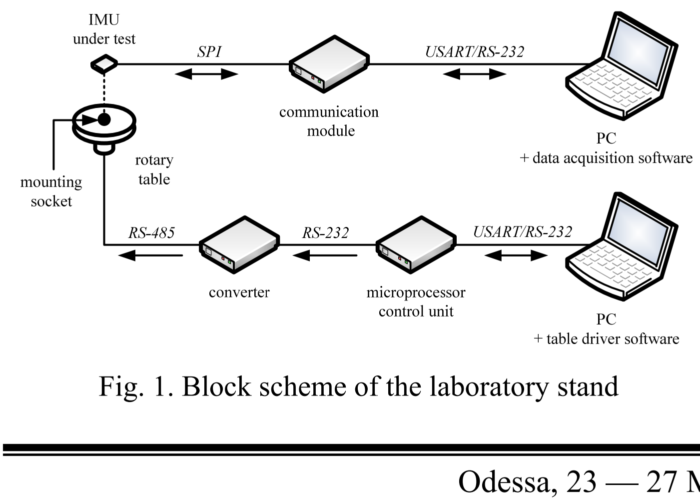

Fig. 1. Block scheme of the laboratory stand

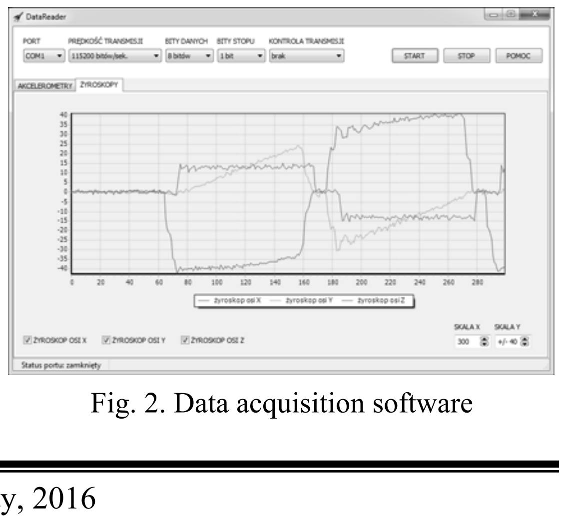

Fig. 2. Data acquisition software

Data acquisition and communication process with tested sensors are supported by communication module based on modified STM3210E evaluation board and STM32F103 microcontroller. The STM32F1-series microcontrollers are the mainstream MCUs equipped with 32-bit RISC-architecture ARM Cortex-M3 microprocessor and several communication interfaces, i.e. SPI (used here to receive measurement data from sensors) and USART (configured here for communication with PC via RS-232 protocol).

Data acquisition software (Fig. 2) and table driver application have been developed using the Embarcadero RAD Studio XE3 environment [4]. Embedded programs have been prepared in Keil μVision 4 IDE.

Sample time courses of measurement data obtained during the test run of proposed laboratory stand are shown in Fig. 3. Signals from each measurement channel of IMU (placed on rotary table and fixed in the handle socket) were transmitted by communication module to the PC, visualized on the screen and saved to the disc in CSV file format. Data acquisition software was also used to compute average value x_{av}, variance σ^2 and standard deviation σ for all measurement variables registered under static conditions, and to find indication errors of angular sensor position (returned by the angular rate integrator and understood as a discrepancy between initial and final position of the IMU) for each dynamic test set.

Summing up, proposed laboratory stand includes several specialized hardware and software solutions for inertial sensor verification, which can be useful during IMUs testing process. Especially, the tools for multiple repetition of sophisticated measurement tasks in unchanged conditions and the tool set for creation of user-defined test procedures are noteworthy.

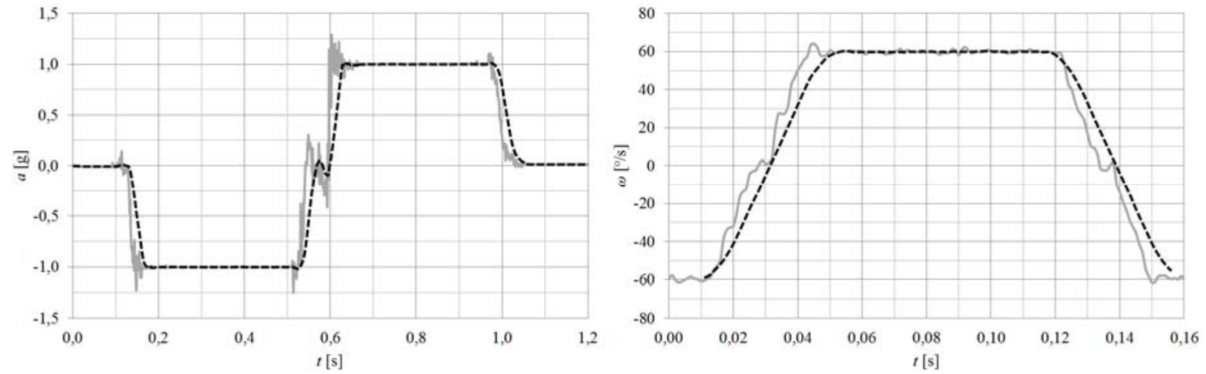

Fig. 3. Sample time courses of acceleration and angular rate collected by data acquisition software: solid line – ADC output signal of IMU sensor, dashed line – internal FIR filter output signal

REFERENCES

1. Bużantowicz W.: Computer-aided missile autopilot analysis and synthesis, Mechanik (in Polish – in press).
2. Bużantowicz W., Miernik J., Pietrasieński J.: Fin actuator transfer function of the anti-aircraft missile: modeling and approximation, Mechanik, Vol. 88, No. 7(CD), 2015, pp. 83-92 (in Polish).
3. Pietrasieński J., Dzięgielewski K.: Object maneuver registration using MEMS sensors, Mechanik, Vol. 86, No. 7(CD), 2013, pp. 643-649 (in Polish).
4. Warchulski J., Warchulski M., Bużantowicz W., Mucha G.: Use of FireMonkey platform during startup and testing of microprocessor systems, Mechanik, Vol. 85, No. 7(CD), 2012, pp. 945-950 (in Polish).

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Лабораторная установка для тестирования и верификации инерционных датчиков

В статье описано лабораторное рабочее место для проведения тестирования и верификации интегрированных измерительных модулей, а также представлены образцовые результаты динамических испытаний инерционных гироскопических и акселерометрических датчиков.

Ключевые слова: метрология, лабораторное рабочее место, интегрированный модуль измерения, инерционный датчик