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THE APPLICATION OF A TEST STAND MODELING THE INVERTED PENDULUM PHENOMENON IN THE INVESTIGATIONS OF THE METHODS OF STABILIZATION OF THE AERIAL MAST POSITION

The paper presents the results of investigations related to the possibilities of control of the radio aerial mast carried out on a test stand reproducing the inverted pendulum phenomenon using servo drives and LabVIEW environment. The authors present individual components of the stand and the measurement equipment used in the experimental investigations.

Keywords: aerial positioning, servomechanism, LabVIEW environment

1. INTRODUCTION

In some design solutions, the application of rigid fitting of an aerial will not guarantee optimum operating conditions of a communication device. Rigid fitting of directional aerials on an object dynamically changing its position may lead to an interruption of the radio signal transmitted by the device.

Due to the increasing popularity of small flying objects it has become necessary to implement better control over unmanned flying objects. One of the possibilities of such control is to equip drones with transponders that allow identification of objects fitted with such devices in the airspace. Active transponders ensure identification of the greatest range of flying objects. Transponders of this type use directional aerials of a high range of the transmitted signal. Components of this type are used in, inter alia, air traffic control (ATC) [Gotfryd, Pawłowicz and Pitera 2015].

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The above hints that it may be necessary to seek alternative methods of control of aerial positioning on aircraft fuselages with precise automation and real time actuation.

The TEST STAND

The investigations were carried out on a 2DOF Inverted Pendulum test stand by Quanser. The view of the test stand has been shown in Fig. 1.

The test stand used in the investigations was fitted with a system of two servomechanisms responsible for the control of the position of the arms of the stand in the X and Y axes, as shown in the diagram in Fig. 1b. The stand was fitted with a system of four encoders. The encoders convert the recorded angular displacements into electrical signal [Nowakowski 2005]. Two of them read the current position of the pendulum in the X and Y axes working as the aerial mast during the experiment. The other two encoders send the current position of the electric motors used in the test stand to the control device.

a) b)

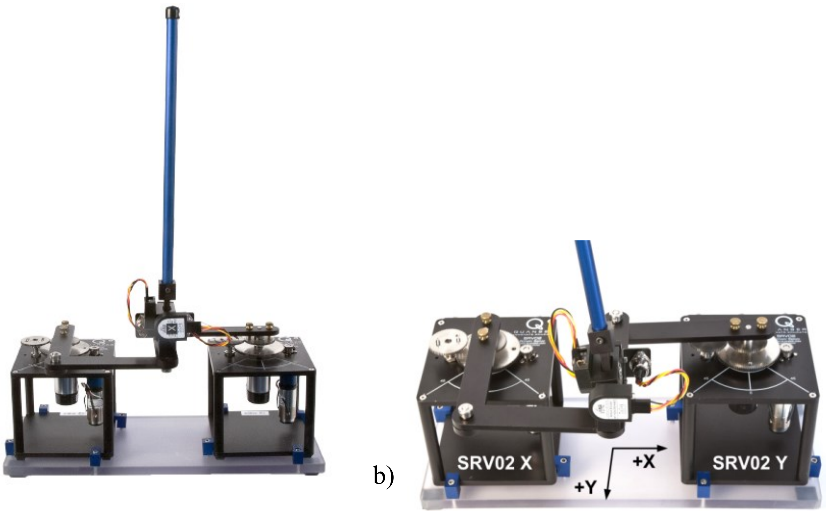


Fig. 1: The test stand [Quanser 2012]

The test stand was connected through an amplifier and two Q1-cRIO Quanser cards in a dual system to the CompactRIO cRIO-9024 device by National Instruments. The CompactRIO device was responsible for the control of the entire system and for collecting the obtained results in the LabVIEW environment [Apkarian 2012].

2. RESULTS FOR THE EXPERIMENTAL INVESTIGATIONS

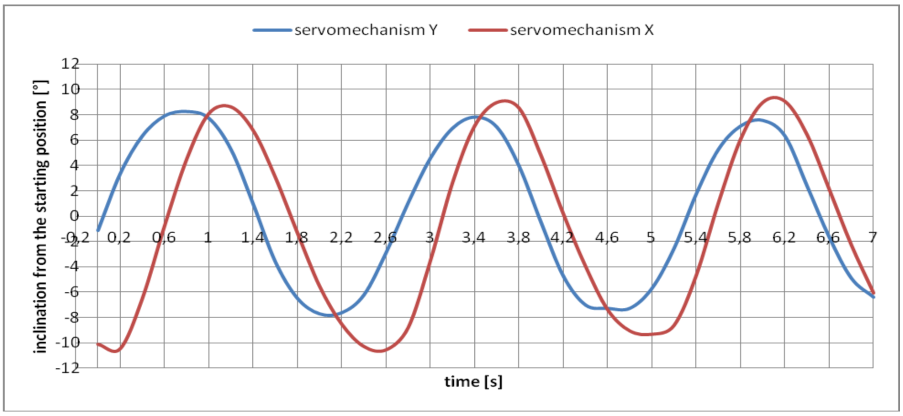
During the investigations, the authors carried out measurements of the pendulum displacements from the neutral position. Initially, the measurements were carried out on a flat surface. The next step included a test of a dynamic change of the pendulum position against the surface on which it was placed. The test was to reproduce the dynamic change of the position of the aircraft fuselage during the flight as well as the influence of this change on the behavior of the system controlling the mast position.

The position of the servomechanisms during the process of maintaining the mast's vertical position in a stationary test has been shown in graph 1.

Graph 2 presents the angle of displacement of the aerial mast in two axes in the stationary test.

The position of the servomechanisms while maintaining the mast in the vertical position in the dynamic test has been shown in graph 3.

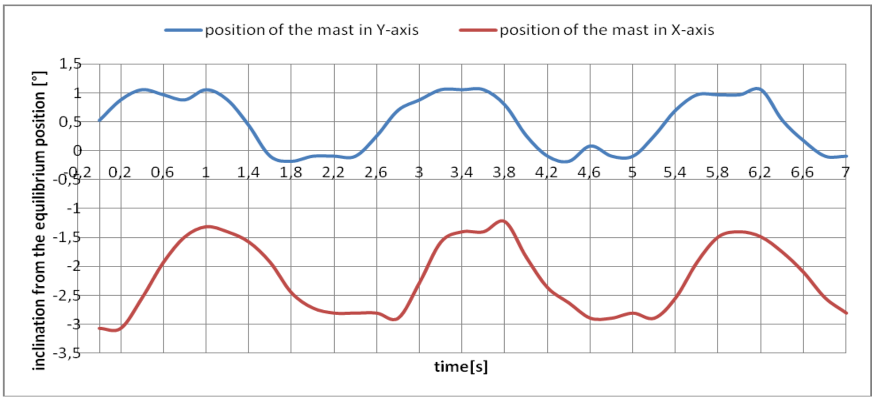
Graph 4 presents the angle of displacement of the aerial mast in two axes in the dynamic test.



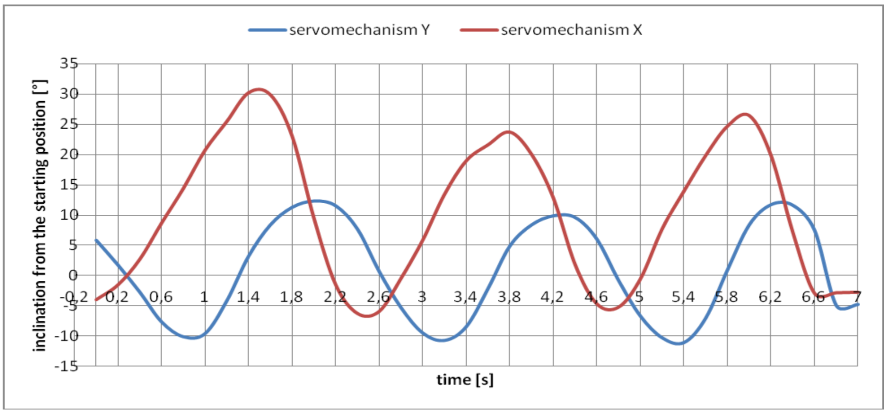
Graph 1. Position of the servomechanisms in the stationary test [Judt 2015]

3. CONCLUSIONS

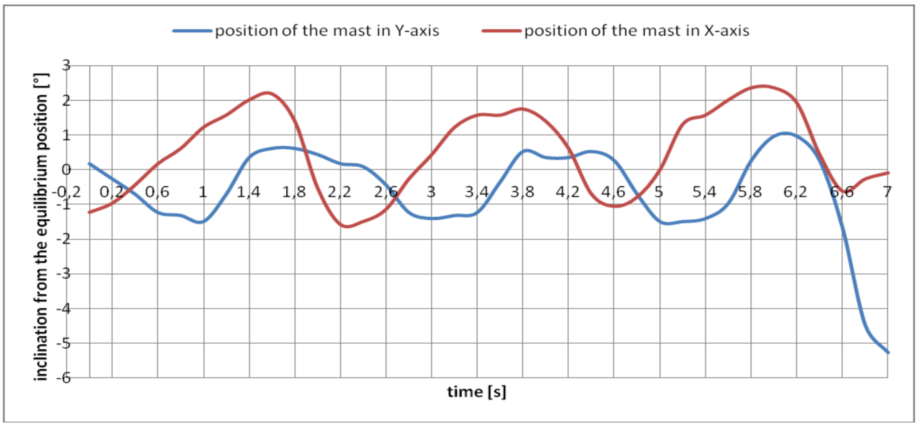
Based on the performed experimental investigations for the stationary test and the dynamic change of the displacement, we may confirm that the operation of the test stand in the stationary test is more uniform. When the test stand operates under stationary conditions, with a high level of accuracy we may predict how the stand will operate.



Graph 2. Position of the mast of the inverted pendulum during the stationary test [Judt 2015]



Graph 3. Position of the servomechanisms in the dynamic test [Judt 2015]



Graph 4. Position of the mast of the inverted pendulum during the dynamic test [Judt 2015]

Graph 1 clearly shows the angular displacement from the initial position of both servomechanisms while the obtained motion trajectory of arms X and Y assumes a shape of a periodic trigonometric function (sine).

The analysis of the obtained motion trajectory in the dynamic displacement indicates distortions in the operation of the test stand. The trajectory presented in graph 3 is not as uniform as the one obtained in the stationary test. The inflection points in the graph for the motion in the X axis do not correspond to the same angular values of the servomechanism positions. The change in the position of the test stand pertained to its displacement from the vertical position along the X axis. Such an effect was expected. This effect is much less conspicuous for the servomechanism responsible for maintaining the aerial mast in the zero position against the Y axis [Judt 2015].

The analysis of the angular displacements of an aerial mast pulled from the encoders determining the position in the performed stationary test indicate a much greater non-uniformity of this parameter for both realized tests compared the operation of the servomechanisms. The mast displacements obtained in both tests are comparable, yet, greater displacements from the neutral position were recorded for the dynamic tests. An important conclusion of the performed mast position measurements is the uneven distribution of the mast motion on both sides of the set quantity equal to 0° displacement. When adjusting the aerial mast position in the stationary test we may observe that it is possible to keep the aerial in a stable position without obtaining the set value – the Y axis values oscillate around the positive ones, while the x axis values oscillate around the negative ones only. During the dynamic test, at some point the test stand seized due to excess displacement of the aerial mast from the neutral position, which rendered further adjustment impossible [Judt 2015].

The application of modern systems of industrial automation in different branches of technology is a fundamental element of their development. These systems together with state-of-the-art control structures such as the LabVIEW environment, allow better achievements in the area of operation of the applied mechanical, electronic or mechatronic equipment.

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WYKORZYSTANIE STANOWISKA ODWZOROWUJĄCEGO ZJAWISKO ODWRÓCONEGO WAHADLA W BADANIU METOD STABILIZACJI MASZTU ANTENY

Streszczenie

W artykule przedstawiono zebrane wyniki badań określające możliwości sterowania masztem anteny radiowej. Badania przeprowadzano na stanowisku odwzorowującym zjawisko odwróconego wahadła z wykorzystaniem układu serwonapędów oraz środowiska programowania LabVIEW. Autorzy artykułu przedstawili poszczególne elementy składowe stanowiska badawczego oraz niezbędną aparaturę pomiarową wykorzystywaną podczas realizowanych badań eksperymentalnych.

Słowa kluczowe: pozycjonowanie anten, serwomechanizm, środowisko LabVIEW