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AN ALGORITHM FOR THE ADAPTIVE CONTROL OF ANTI HAIL MISSILE LAUNCH RAMPS

BY

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Abstract. This paper presents the results obtained by the Centre for Innovation and Technology Transfer Craiova regarding the complementary equipment that was necessary for developing the anti-hail system in Romania, and one of the research directions, the adaptive control of the anti-hail missile launch ramps.

Key words: positioning system; adaptive control; anti-hail system.

1. Introduction

Anti-hail systems are known for over eighty years (Manolea, 2014) and deployed for over fifty years. However, the Romanian Anti-Hail System was created in 1999. The University of Craiova, with its Center for Innovation and Technology Transfer CIIT, performed several doctoral studies and contractual projects regarding the complementary equipment for the National Anti-Hail System, starting from specific collaborative projects with the Technical University of Moldova. Credited the demonstrated expertise and the accomplished complementary equipment, the University of Craiova-Innovation

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and Technology Transfer Centre became part of General Designer of the Romanian National Anti-Hail and Precipitation Growth System

One of the equipment, the subject of the doctoral and contractual research performed (Contract 45067; Nicolae, 2015; Şulea, 2012), was the anti-hail missile launch ramp.

This document presents an algorithm for automatic adaptive control of the launch position, which takes into account a set of restrictions and optimal operating conditions.

2. The Mechanical Structure of the Ramp and Operating Restrictions

The mechanical structure of the present ramp (Fig. 1) contains a set of components that allow the rockets to be fixed and their orientation (Fig. 2) in two directions: azimuth and elevation.

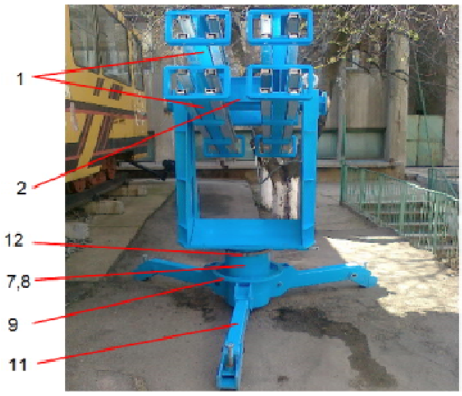

Fig. 1 *a* – Front wiew.

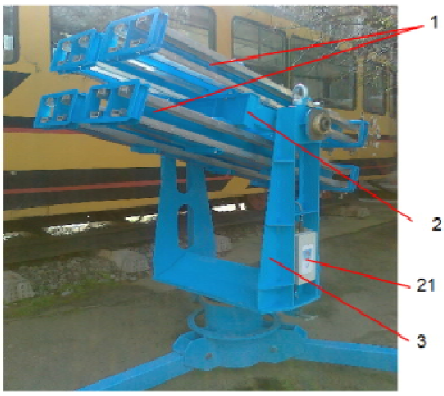

Fig. 1 *b* – Right view.

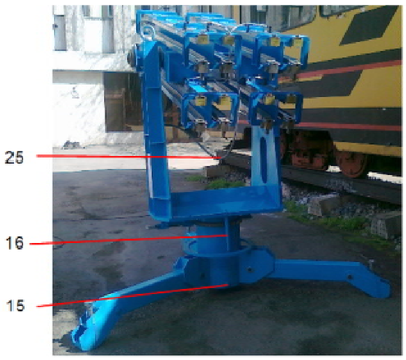

Fig. 1 *c* – Rear view.

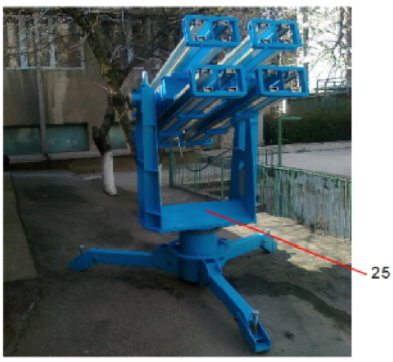

Fig. 1 *d* – Left view.

Fig. 2 – Placing the ramp at the missile launch points.

These components include the launching beam (1), on which the rocket is mounted, the elevation swing (3), which provides the vertical adjustment of the launching direction, the azimuth shaft (7), which is installed inside the main vertical post (8) and provides horizontal orientation of the launching direction.

For the proper operation of the ramp, several restrictions are imposed, including:

– the maximum elevation angle for the launch of a missile is 85º;

– the minimum elevation angle for a missile's launch is 20º;

– the rotation of the azimuth shaft must not exceed 360° to avoid damaging the power supply cables and the sensor cables attached to the ramp.

The following restrictions, which can be done automatically, according to the algorithm proposed in the paper, can be added to these necessary restrictions, which are made in the current construction by mechanical methods:

– moving from the current standby position to launching position on the shortest path;

– optimal positioning, in minimum time, for maneuvers performed during alarm periods;

– optimal positioning with minimal energy consumption for current checking maneuvers, home positioning, or if the available battery power is below a set threshold.

3. Structure of the Drive System Used for Positioning of the Launch Ramp

The drive system (Fig. 3) allows independent or correlated movement on the two axes, azimuth and elevation, depending on the launching coordinates transmitted from the control center. The movement is accomplished using of two synchronous motors with permanent magnets powered by electrical smart drives (Fig. 4).

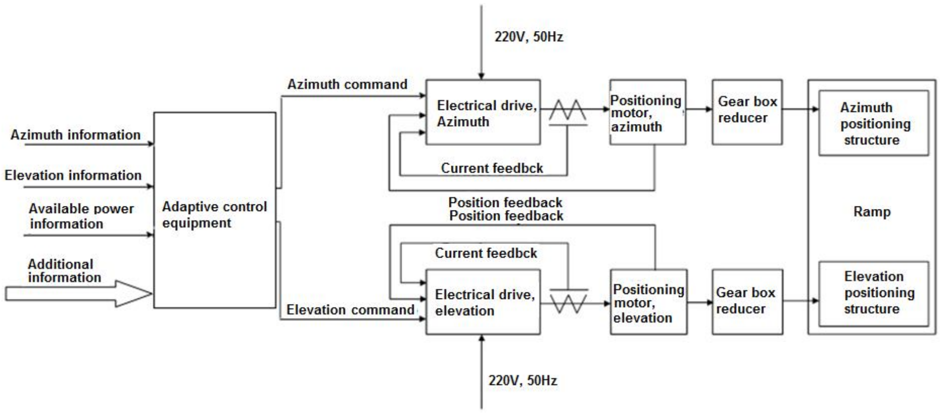

Fig. 3 − Block diagram of the drive system used for positioning of the launch ramp.

Azimuth and Elevation coordinates can be transmitted manually to the positioning system, from a touchscreen (Fig. 5), or directly.

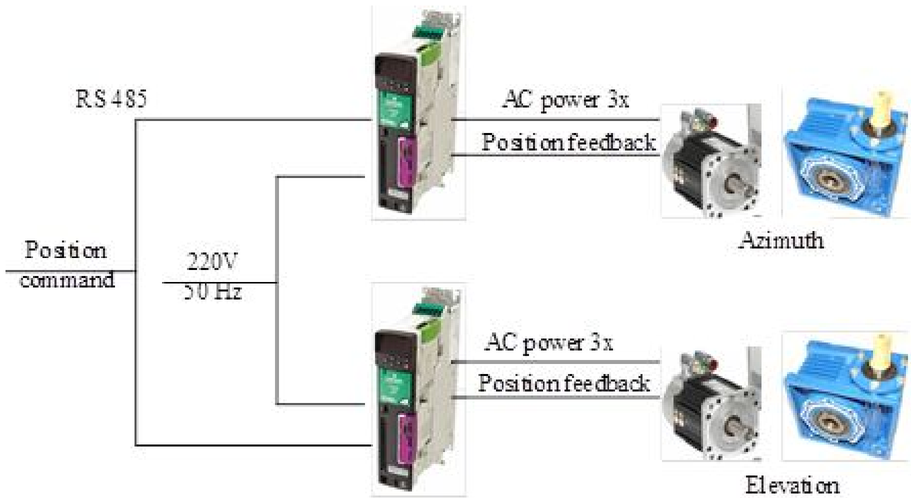

Fig. 4 − Structural diagram of the drive system used for positioning the anti-hail missile launch pad.

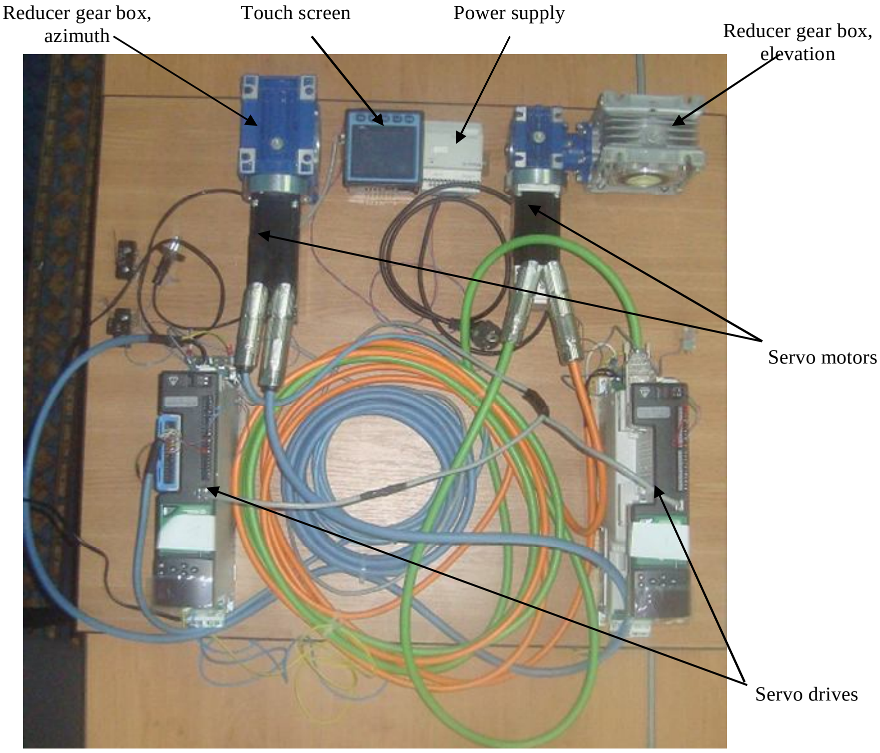

Fig. 5 − The experimental model of the positioning system.

4. Description of the Algorithm for the Adaptive Control of the Positioning System

Considering the destination of the equipment, positioning can be done:

- entirely manual;

– semiautomatic, the operator enters the coordinates from the touch screen;

– automatically, the coordinates being transmitted to the positioning system from the control center, and the validation is done either by the operator at the launch point of the missile or by the operator in the control center;

– automatic adaptive, the control equipment (Fig. 3) ensures that the additional conditions are met, by which the positioning system approaches a smart system.

The adaptive command algorithm is presented assuming that the ramp is in the standby position (Fig. 6).

Elevation coordinates are verified:

$$I^* > 20º,$$

respectively

$$I^* < 85º.$$

If these conditions are not met, warnings messages are signaled and appropriate decisions are made.

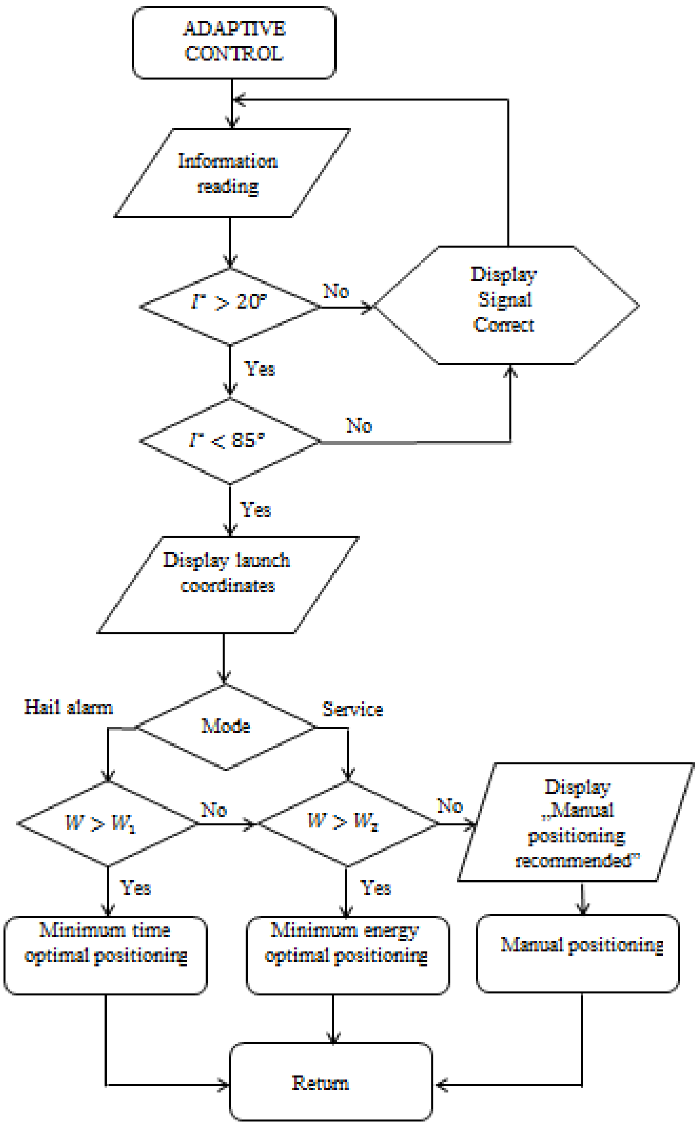

Fig. 6 – Logic schematic for the adaptive control of the positioning system.

Operation mode (hail alarm or service) is verified. If the positioning is done in hail alarm mode, the maximum priority condition refers to the available energy in the accumulator batteries that must be sufficient to power the launch of the missile, and therefore the following conditions are checked:

$$W > W_1,$$

where: W_1 represents the minimum energy level sufficient for any operating mode, respectively

$$W > W_2,$$

where: W_2 represents the energy alert level.

Depending on the results of the comparisons, the following adaptive decisions are taken:

– the positioning command is automatically executed after a law that allows for minimum time positioning (Manolea, 1994);

– the positioning command is automatically executed after a law that provides minimal power consumption (Manolea, 1984);

– it is recommended that the positioning is done manually to keep the energy reserve necessary for ignition of the missiles.

5. Conclusions

This paper presents the results obtained by the Centre for Innovation and Technology Transfer Craiova regarding the complementary equipment that was necessary for developing the anti-hail system in Romania. The initial results were obtained through doctoral research, then developed by contract research and accepted for industrial application by Electromecanica Ploiesti, the manufacturer of the anti-hail equipment.

The adaptive command is the stage of doctoral research (Stepan, 2017) through which the automation system approaches an intelligent system and exploits the hardware resources of the equipment that has been achieved so far.

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ALGORIM PENTRU COMANDA ADAPTIVĂ A RAMPELOR DE LANSARE A RACHETELOR ANTIGRINDINĂ

(Rezumat)

Lucrarea prezintă rezultatele obţinute de CITT Craiova în domeniul echipamentelor complementare destimate sistemului naţional antigrindină din România şi una dintre direcţiile de cercetare, respective comanda adaptivă a rampelor de lansare a rachetelor antigrindină.