DEVELOPMENT OF AN ALGORITHM FOR CONTROLLING ANTENNA DRIVE GEARS OF SPACECRAFT USING PROGRAMMABLE LOGIC CONTROLLER SIEMENS S7-1200

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Rocket and space industry of Russia is one of the most developed in the world. According to [1], Russia has occupied 11% of the world market of space services and the Russian government has plans to occupy almost a quarter in the nearest future. There are more than 60 organizations and companies providing products for the space industry in Russia. One of the most productive is JSC Information Satellite Systems - Reshetnev Company that provides more than 70% of all Russian satellites.

Nowadays, results of scientific, research and engineering activity in the aerospace industry have found wide application in all spheres of modern live. That is why it is impossible to overprice the importance of space developments. The GLONASS navigation system, different systems of geolocation, communication, spying etc. are just the most popular examples. Wide spreading occurrence of these technological solutions in everyday life additionally stimulates further researches in the aerospace sector, since their use on earth is impossible without having presence in space. It is necessary to constantly produce and modify new spacecrafts, because modern satellites have a short longevity (4-6 years, on average). New modifications should be mainly aimed at increasing longevity of spacecrafts and reducing launching rates.

JSC Information Satellite Systems - Reshetnev Company provided TPU with several systems that ensure functioning of a spacecraft – an antenna rotation system (SRA) and solar drives (SD). Within the current study we have analyzed SRA. SRA consists of several structural units: a mechanical block (MB), and an electronic block (EB). EB contains a control unit drive (CUD) and equipment for calibration and testing (CTE).

The MB of SRA contains two drive gears that allow antennas to rotate perpendicularly in a given range with a predetermined precision and transmitting UHF signals. The MB is also designed to rotate a rotor of a rotating transformer (RT) to obtain information about the angle of a current antenna position. [2]

The layout and axes of the MB are shown in fig. 1.

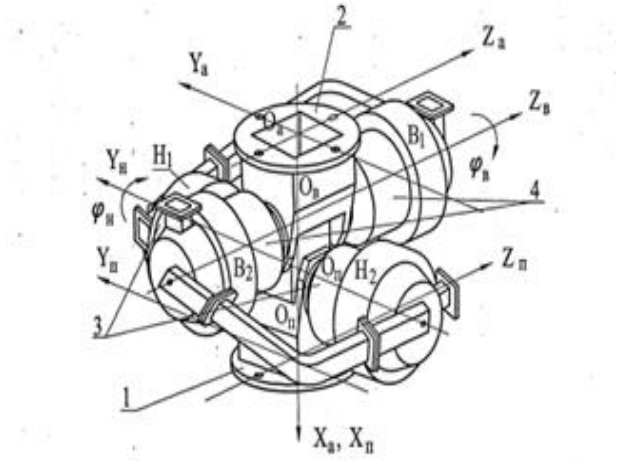

Fig. 1. The layout and axes of MB of SRA

1 –MB boarding plane;
2- antenna boarding plane ;
3 –lower drive (H);
4 –top drive (B);
ϕ_H – rotating angle of the H-drive;
ϕ_B –rotating angle of the B-drive;
O_BZ_B –axis of rotation of the B-drive;
O_HZ_H –axis of rotation of the H-drive;
X_n, Y_n, Z_n - coordinate system associated with the boarding plane of MB of SRA;
X_a, Y_a, Z_a - coordinate system associated with the antenna boarding plane.

A control unit of drive gears (CUDG) is a programmable logic device that performs the following functions:

- receiving control commands;
- positioning the angle of the drive gear depending on a numerical driving signal value;
- management of the drive gears while working in a manual control mode with a constant speed;
- generating information about the RT turn angle in a form of a sequential code;
- switching circuits of heaters that are installed on power supply lines;
- generating telemetric and technological signals. [3]

CTE (calibration and testing equipment) of SRA is an imitation of an onboard computer of the spacecraft. The main goal of the CTE is to test SRA in special conditions. CTE is a large-sized and heavy device and that is the reason why it was not provided by JSC

Information Satellite Systems - Reshetnev Company. However, it is a mandatory element of the whole system, thus it was necessary to create a different CTE with the same signals and parameters at TPU.

Selection of a logic device that could be used as CTE for the antenna rotation system and analysis of technical documentation of the investigated system are the primary goals of our study.

It was decided to choose a programmable logic controller (PLC) Siemens s7-1200 as a base of CTE. This PLC allows controlling a wide variety of devices and is commonly used in automation because of its functionality. It is not as big as the old CTE, it has small size (110x100x75) and weight (475 g), which is a real advantage because the price of in-orbit delivery depends on these parameters and is usually very high. Because of a wide range of possible applications this PLC may also be used in education as a workbench for different labs in different subjects.

The software STEP 7 Basic allows programming the PLC and is a very comfortable environment to control and edit logic. It supports two different programming languages. They are LAD and FBD.

Ladder logic has evolved into a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware

The Function Block Diagram is a graphical language for programmable logic controller design, that can describe the function between input variables and output variables. A function is described as a set of elementary blocks. Input and output variables are connected to blocks by connection lines [4].

The interface of STEP 7 Basic and an example of a simple LAD program are shown in fig. 2.

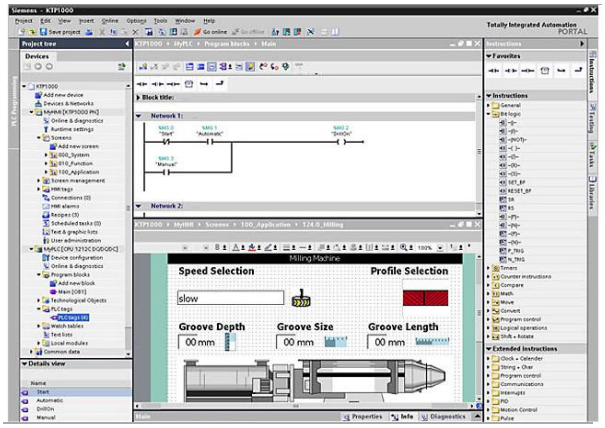

Fig. 2. The interface of STEP 7 basic

PLC Siemens S7-1200 was selected because of the following parameters:

- Availability of the necessary amount of inputs and outputs;
- suitable power supply level (Normally the PLC works at 24 V but it is able to work in the range from 20.4 V to 28.8 V. SRA drive gears require voltage in the range from 23 to 31 V.);
- JSC Information Satellite Systems - Reshetnev Company uses Siemens' controllers for the purposes of controlling different technical processes;
- versatility;
- durability and reliability;
- small weight and size without sacrifice of functionality;

It is also necessary to program the PLC so that it could perform a vast variety of commands such as to switch on/off manual gear control, heater sections, or CUD.

The selected controller has many abilities. Its broad functionality, as well as versatility of the researched system as a whole allows using it as a workbench for many labs in different subjects to study electric drive systems (studying of electric and mechanical characteristics of drive gears), microprocessor engineering (programming with STEP 7) and mathematical simulation (using real systems as an object of study). The developed workbench would be very useful and students would get experience of working with a real system.

At the moment, the technical document of each structural unit of SRA has been analyzed and functioning of the system has been studied. Hardware implementation for CTE was selected and the main algorithms of processing input-output relations received from the CUD have been developed.

Literature

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