Building automation system of payment platform weight component for large spacecraft reflector

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Abstract. Considered Design and the logic of opening large convertible antenna. The necessity of compensation weight component in the assembly and testing of the design. Given the logic of the movement elements of power spokes, concluded that the use of the tracking system to compensate for the weight component. The analysis of the existing equipment and control systems. Produced selection of the manufacturer of automated equipment that meets the stated objectives of management and control. It is concluded that the design component of the weight compensation system based on servo controllers and sensors combined platform automation, controlled by special software. The structure of the platform automation, consistent workflow testing. It defines the principles of interaction between subsystems of the weight compensation component for receiving, processing and monitoring of process parameters testing. It is concluded that the proposed system can be integrated into the automation system and the perspective of process control testing of disclosure of large spacecraft.

Keywords: system of compensation weight component; spacecraft, bulky reflector, the control system, the model, the automation platform module, servo, controller\textsuperscript{6}, software.

Introduction. In connection with the introduction of the industry bulky mechanical systems spacecraft became necessary to find new, but it is quite simple and effective ways of working out these mechanical systems at the stage of terrestrial experimental testing, since the use of traditional methods either do not meet the requirements, or cannot be used due to the constructional features.

At various spacecraft conducted a series of experiments for the deployment of large-sized antenna structures. Analysis of existing in the world market of large transformable reflectors showed that, despite some progress in this area, only a few of them are able to ensure the accuracy of weightlessness respective predetermined shapes and the necessary rigidity. It is not possible always to achieve a reliable disclosure. The reason is the violation of technology of the following steps:

- manufacture of parts and assemblies based on the resource characteristics of the structure;
- high-precision assembly bench on the complex;
- system the test antenna.

For all of the existing spacecraft at the present time must be performed a number of tests, which require the elimination of the weight component for constituent elements of a design, to avoid deformation or destruction under the influence of gravity. To fulfill this
requirement use system of compensation weight component. These systems may find their application in the test operation of mechanical systems at disclosure processes transformed antennas, truss reflectors in different shapes and sizes, of solar panels and other designs. [1-4]

Appointment. The compensation systems for weight component intended to compensate for the moments of the forces acting with respect to the root of the hinge assembly relative to the intermediate joint assembly relative to the hinge assembly cantiing spokes by weight of units, and the moving parts of the reflector, including separately from the forming structure of tapes deployment mechanism from canvas and other essential structural components of the reflector. Configure and verify the operation of the reflector.[5]

The system of compensation weight component should provide a job with a reflector, a key element of the support structure, which is the power spokes (Figure 1), which define the desired stability of the work surface under the influence of factors operating. Consider, the basic principles of the compensation system of modules required to provide compensation for the weight of the constituent elements of the antenna power spokes.

![Figure 1. Power spoke](attachment:image.png)

1 - root element; 2 - terminal units; 3 - folding unit; 4 - Intermediate hinge assembly; 5 - root hinge assembly.

To ensure the required dimensions in the transport position, the power spike has a convertible structure and is driven to its working position by means of a sliding mechanism of the mast. To construct the trajectory of the center of mass at the time of disclosure of the spokes, a table 1 to 20 units, and the provisions of the strut relative to each other during the disclosure of the antenna.

| Conditional status spokes links | Angles disclosure | Spoke root | Spoke end | Struts |
|---------------------------------|------------------|------------|-----------|--------|
|                                 | α1 | α2 | Y, mm | X, mm | Y, mm | X, mm | Y, mm | X, mm |
| 1                               | 0  | 0  | 2.48  | 2313.37 | 167.1  | 2330.16 | 271.39 | 1534.75 |
| 2                               | 0  | 10.247 | 2.48  | 2313.37 | 465.55  | 2371.19 | 709.66 | 1607.02 |
| 3                               | 9.024 | 10.247 | 365.31 | 2284.35 | 831.72  | 2268.82 | 952.95 | 1475.81 |
α1 - the angle between the axis of the mast and the needle root; α2 - the angle between the needle and the needle root end.

According to the data of Table 1 plotted the center of mass of the root needles, needles and strut end (Graph 1).

|   | 4   | 15,143 | 20 | 606,71 | 2232,4 | 1355,26 | 2180,68 | 1526,52 | 1396,96 |
|---|-----|---------|----|--------|--------|---------|--------|--------|---------|
| 5 | 20,827 | 30 | 824,85 | 2161,32 | 1856,49 | 2070,93 | 2086,24 | 1302,31 |
| 6 | 26,143 | 40 | 1021,52 | 2075,62 | 2328,41 | 1948,97 | 2620,16 | 1201,69 |
| 7 | 31,043 | 50 | 1195,08 | 1980,78 | 2768,04 | 1827,27 | 3125,07 | 1108,88 |
| 8 | 35,301 | 60 | 1338,88 | 1886,56 | 3167,92 | 1728,72 | 3595,02 | 1049,65 |
| 9 | 38,624 | 70 | 1445,95 | 1805,8 | 3519,72 | 1685,15 | 4022,89 | 1060,35 |
| 10 | 41 | 80 | 1519,57 | 1744,3 | 3822,27 | 1713,52 | 4403,89 | 1161 |
| 11 | 42,875 | 90 | 1575,84 | 1693,64 | 4084,82 | 1794,79 | 4738,68 | 1330,01 |
| 12 | 44,751 | 100 | 1630,45 | 1641,13 | 4318,52 | 1894,75 | 5031,51 | 1527,03 |
| 13 | 46,902 | 110 | 1690,88 | 1578,8 | 4529,99 | 1988,05 | 5286,52 | 1721,15 |
| 14 | 49,401 | 120 | 1758,12 | 1503,57 | 4721,07 | 2061,81 | 5505,96 | 1895,95 |
| 15 | 52,239 | 130 | 1830,41 | 1414,67 | 4891,15 | 2110,11 | 5690,6 | 2043,4 |
| 16 | 55,518 | 140 | 1908,33 | 1307,66 | 5043,81 | 2118,17 | 5845,57 | 2145,91 |
| 17 | 59,556 | 150 | 1995,67 | 1170,04 | 5189,93 | 2051,64 | 5886,04 | 2797,27 |
| 18 | 64,682 | 160 | 2092,22 | 987,06 | 5336,97 | 1873,35 | 5967,21 | 2675,42 |
| 19 | 71,247 | 170 | 2191,29 | 741,58 | 5482,94 | 1543,53 | 6064,13 | 2381,61 |
| 20 | 79,906 | 180 | 2278 | 403 | 5613 | 991,2 | 6174,5 | 1842,6 |

Graph 1. The center of mass of the root spoke, spoke and end strut.

The graph shows that the trajectory of the links and the strut rather complicated, requiring the use of the tracking system to compensate for the weight of the component elements in the process of working out the disclosure antenna in ground conditions.[6-8,10]

**Production system management tasks.** To implement compensation component of the spokes during assembly and testing, it is necessary to organize a three-point connection, are in
the theoretical center of mass of the root, and end folding units with the module component of the weight compensation system. Communication with the executive system compensation follower weight component will be implemented through a flexible inextensible sling.

Actuators compensation system of the weight component will be three carriages moving along the rail and ensure a certain predetermined deviation from vertical flexible lines, as well as three drive winder flexible lines to changes in the length of the flexible lines, changing the coordinates of the centers of mass units. From the center of gravity of links and their trajectories are added acceptable compensation system moves carriages weight component.

The module compensation system of the weight component must meet the following basic conditions: to ensure the maintenance of a predetermined force in flexible slings and control, tracking deviation from vertical flexible slings and control the angle of deflection on the entire trajectory of the centers of mass units. The reaction of the actuator system must provide the necessary dynamics in the process of opening an antenna.[4,9]

**The proposed platform automation.** Analysis of domestic and foreign market of automated equipment showed that domestic producers lack the necessary range.

The equipment satisfies the necessary conditions only firms "Siemens", "Rockwell Automation" and "Mitsubishi Electric".

Analysis of equipment from Siemens shows that it does not satisfy the mass-dimensional parameters and the methods of construction of the SCADA-system.

Consider the equipment of firm "Rockwell Automationr". Distributors of this equipment are ready to put it, but does not deal with technical support and maintenance projects.

Analysis of the equipment of the Japanese firm Mitsubishi Electric demonstrated that it meets the requirements for dimensional parameters, specifications and software products that can implement an appropriate management system and program shell for the operator system compensation.

In order to implement compensation weight component is offered on the basis of an automation platform MELSEC System Q Mitsubishi Electric. Mitsubishi System Q platform is based on advanced multiprocessing technologies, one system will have multiple processors - processor PLC, motion control processor, the processor control program based on SCADA-system with the possibility of full integration of requests for management and exchange of data on a single platform. In addition a high degree of system availability by using redundant master devices in communication networks, as well as recognition of the break lines and the ability to "hot swap" that allows module replacement during service system.

The traffic management controls synchronizes the connected servo amplifiers, servo motors and a set of required sensors are integrated into the control system for the continuous visualization and tracking the positions of the centers of mass units spokes.

Block diagram of automation presented in Figure 2.
Each module includes a separate control unit, consisting of PLC, motion control module, analogue input module, the module of digital inputs, outputs module, power supply and servo amplifiers located on the chassis. All modules are connected to the base station control with Ethernet. Basic control station consists of a PLC module MES-interface switching Ethernet module and a personal computer with the operating system for positioning controllers and SCADA system. SCADA-system is implemented on the MX4 SCADA - a fully functional system of monitoring and data collection, based on the interface of Windows, which considerably shortens the learning curve, enabling the user to quickly adapt and respond to changes in the process. The SCADA-system programmed basic functions, including locking, alarm, archive data and reports, provides a simple, but important solutions.[12,13]

Visualization works with the control program executed on the operator panel Mitsubishi Electrical GOT2000, which provides the human-machine interface that provides access to process data, allows you to track, manage, and as necessary to change the parameters of the compensation weight component. Automatic control of the process of compensation weight component is constructed in such a way that on the computer screen displays the main menu system, containing functional groups:
- Mode of assembly;
- Test mode;
- Statistics;
- Configuration and diagnostics;
- Active alarms;
- Archive.

Automatic compensation control weight component is to control and maintain the desired process parameters, by the system control operation of the actuators.

With regular tests designed system runs according to the specified algorithm, maintaining the value of certain efforts and the vertical position of the flexible connection of
the entire trajectory of the disclosure of the spokes of the antenna, and also takes into account the impact of dynamic jerks and prescribed emergency situation.

Management system is designed so that the control program set the basic parameters of the compensation weight is:
- The value of the desired tension of the flexible lines;
- Needed speed (or the laws of change of speed) servo tracking upright flexible straps.

Servo motors allow you to set any of the known laws of regulation and set any parameters for a smooth acceleration - deceleration, working out signals from sensors measuring the angle and load cells.

**Conclusion.** As a result of this article, it concluded that the proposed system can be integrated into the automation system and in the perspective of process control testing of disclosure of large spacecraft antennas.

The structure of the compensation system automation platform weight component, consistent process of testing. Designed intuitive man-machine interface, with the possibility of remote monitoring and control settings.

Using the selected automation platform will solve the task management of the compensation system, which will increase its reliability, expand functionality, will be more convenient to use, increase productivity and reduce errors operator to reach the desired level of efficiency of the system as a whole. Such an assessment can confidently assert the qualitative improvement of the system of compensation weight component, which will have greater flexibility and dependability

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