SMALL-SIZE MICRO PROCESSING SYSTEM FOR NANOSATELLITE SEPARATION

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Nanosatellites (NS), the spacecraft with masse from 1 kg to 10 kg – are now able to solve the serious research tasks:

• study of the magnetic field of the Earth,

• analysis of solar radiation in the near-Earth space, photographing the certain areas on the sur-face,

• Mobile Communications "5G" based on NS,

• Development of the transmission of images within the Globalstar system, etc.

With the improvement of the element base of NS, namely, the transition to a fully solid-state structure (1), the level of scientific and technical problems solved will increase significantly. Today it is developed an interesting space project proposed by an international team of physicists, which can help determine the degree of impact of gravitational forces on entangled states of quantum systems. Another important task, both in terms of scientific and applied for the use of a tomographic analysis of the state of the ionosphere, in particular, the spatial distribution of the electron density (2,3) with radiosonde methods, using NS derived colonies on a certain circular orbit and equidistant from each other. The very formulation of the problem of radio, optical tomography of the ionosphere requires precise injection into the certain orbit NS groups in an amount of from 24 to 36 (4), with certain initial velocities in predetermined directions.

To solve this kind of problem can be actively developed at present the automated separation system (5). The most effective in this regard, is NS launch system of magnetic type, because they allow high-precision separation satellites for specified orbits, they small dimensions, weight, and low cost. At the same time, the known separation systems, including magnetic induction usually designed for a small number of launches the satellites with relatively light masses of about 1 kg, or are unable to provide the exact direction of the compartment with the exact value of the initial speed of discharge apparatus. It is known that the direction of the detachable unit in the simplest case can be determined relative to the separation system or the coordinate system associated with the Earth. The last option, despite its relative complexity (6), is most convenient to derive groups into a circular orbit for tasks such as tomography of the ionosphere in the radio and optical bands.

Separation system of the NS groups from delivery vehicles for each unit should solve the following tasks: to orient the main axis of the satellite in the zenith and azimuth directions, make rotation onboard gyroscopes to the certain value of the angular momentum, produce separation of the NS at a predetermined velocity. The most promising of magnetic launch systems contain mechanisms NS swivel launch platform in certain zenith and azimuth directions and magneto ejector informing the detachable unit required momentum. The authors have developed a microprocessor control unit for magnetic induction separation systems department (MISZ), allowing to solve these problems.

Fig. 1 shows a block diagram of a microprocessor control unit MISZ of the mentioned type. This control unit has been designed for a system in which a trigger pulse formed by the mechanical motion of a high-flow solenoid when it current pulse in a constant magnetic field of neodymium magnets. Current pulse in the solenoid is formed by discharging a capacitor (capacitor bank). In the designed MISZ model to generate a magnetic field in the working gap neodymium magnets were used - one as a ring with dimensions: (D = 95, d = 40, h = 20) mm3 another cylindrical (d = 9, h = 20) mm3, it is set in the center of the annular magnet. Thus, the annular working gap created a constant magnetic field, characterized by the induction. In this gap a high current solenoid containing 90 turns of wire diameter d = 1 mm, the discharge of the capacitor having a capacitance 10,000 uF and potential of 100 V (ELZET CD294), the solenoid current pulse is excited.

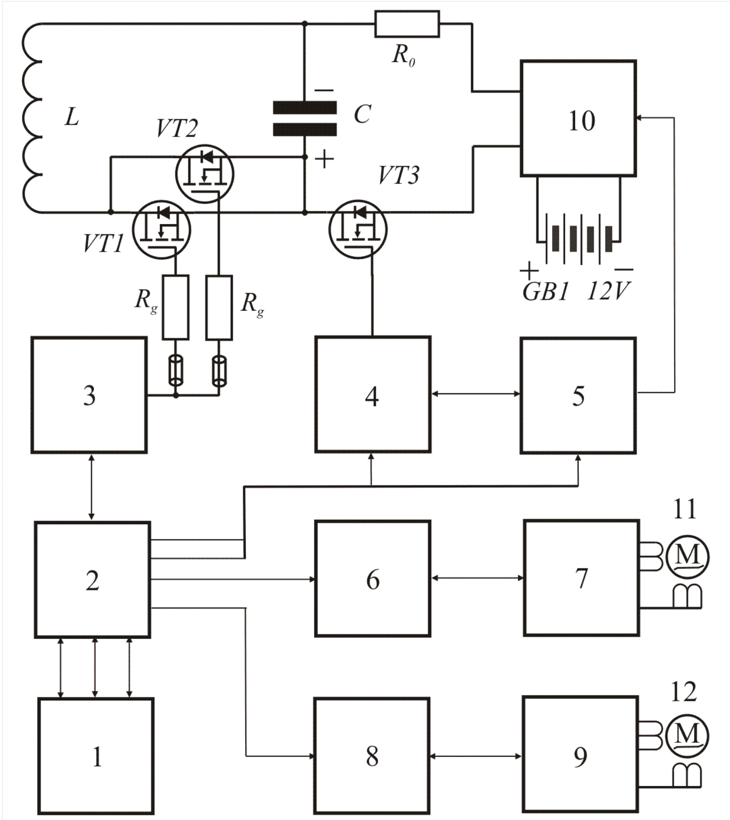

Figure 1: Block diagram of the control MISZ
where: 1-the communication module with on-Board computer means of delivery; 2-microprocessor; 3-shaper bit of impulse; 4-control module of charge of the capacitor; 5-control unit voltage converter; 6,8- shapers control signals SE (Stepper Engine); 7,9-mover SE; 10- voltage converter; 11,12- SE

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arameters of the discharge RLC circuit are chosen so that the fast fading has been im-plemented quasiperiodic process duration is equal, with 94% of its capacitor charge sends the formation of the discharge current during the first half period which lasts. The energy stored in the capacitor is consumed for the creation of the magnetic field energy induced by a solenoid coil for heating, etc. The current pulse in the solenoid is able to make a mechanical work by moving it in the gap eductor has the same duration at maximum amplitude, which makes it possible to obtain mechanical work of 4.365 J. This work is spent on work against the forces of friction in the mechanism of magnetic ejector, on work to overcome the elastic forces of the damper spring and on work of the separation of nanosatellite, i.e. giving it a certain kinetic energy. In this case, the maximum kinetic energy imparted to the NS is about 2.46 J, which gives the ability to separate NS with masses up to 4 kg with velocity (1 ÷ 2) m / s.

The above analysis of the processes occurring in the discharge of magnetic ejector and conducted mathematical modeling of different variants of these processes allowed to define the basic parameters of the control signals MISZ and to develop schemes key device, a voltage converter, signal generators, etc.

As key in this unit were used high-current FETs MOSFET IRFP4468PBF, which are parallel to VT1, VT2 (see Fig. 1), each such transistor is able to pass a current up to 290 A at a voltage drain - source voltage of 100 V. The control signal is applied to the key from waiting univibrator - 3, which is controlled by a microprocessor - 2. duration of the control pulses is selected adjustable between 0.0005 to 0.001 s, which makes it possible to set the certain NS separation velocity. Charge on the capacitor (capacitor bank) by using a voltage converter - 10, which is formed by two push-pull driver IR2151, which switch pair FETs IRF3205 100 kHz. Studies had shown, this oscillator circuit has been very reliable and stable operating over a wide temperature range (± 50 ° C). The output voltage of 110 V at 10 A. The charging time of the capacitor is 10, control of the charge carried by an electronic key to fulfillment of FET VT3 IRFP150N, connected to the control unit battery - 4. Voltage converter turns on and off in synchronization with the key VT3, the charge control module - 4 signals microprocessor - 2. control unit is a voltage converter RS - trigger stress are the electronic keys made FET 2T3336 that switch inputs 4, driver IR2151 to common, stopping so , the process of generation.

As a microcontroller prototyping version was used microprocessor of TMS320C2xx family. Important basic properties of microprocessors TMS320C2xx, allowing them to be effectively used in satellite systems are:

• compatibility with software C1x, C2x code families;

• extended instruction set to accelerate DSP algorithms and support con-constructions high-level languages;

• High efficiency (up to 40 MIPS);

• Low energy consumption due to energy-saving mode.

Modified Harvard architecture, which provides separate instruction and data bus allows simultaneous select commands and operands. The possibility of exchange between program memory and data increases the flexibility of the microprocessor. Thus, the coefficients located in program memory can be transferred to the data memory, thus saving memory allocated for the coefficients. The processor has increased compared with the previous families, the amount of on-chip memory and reprogrammable non-volatile flash-memory. The presence of 4-stage pipeline allows TMS320C2xx perform an average of one command per clock. TMS320S2hh microprocessor comprises means of interrupt control, redo operations, call subroutines and functions.

Setting the corresponding values of azimuth and zenith angles relative to the orientation of delivery vehicles by using stepper motors - 11, 12, which, through the standard drivers - 7, 9, and signal conditioners control - 6, 8, connected to the microprocessor - 2. MISZ used in this miniature stepper motors FL20STH, drivers SMD - 1.8, control units SMD - 15.

Separation is reduced to the following operations that are controlled by the microprocessor:

• After reaching a certain height, on-board computer delivery systems (BKSD) through communication module informs the microprocessor MISZ its location and orientation in space relative to the control system related to the Earth.

• Then BKSD instructs the robot arm to install the NS on the separation platform MISZ.

• Based on the data BKSD MISZ microprocessor calculates the startup parameters - zenith, azimuthal angles, the kinetic energy of satellite, single-axis angular rate gyros, the charging time of the capacitor bank, etc.

• Produced charge the capacitor bank, the charge level is controlled by the microprocessor.

• Simultaneously with the charging process, installs a given zenith angle using the drive mechanism driven by SM - 11.

• Further provided NS orientation azimuth direction by using SM - 12, which drives a mechanism of rotation.

• After that, the rotation is made, uniaxial gyroscope rotors mounted on the NS to a predetermined angular velocity.

• Then NS is launched at a given velocity, which is determined by the assigned time interval corresponding to the capacitor discharge comands MISZ microprocessor.

• To start the next NS procedure is repeated with the amendments to change the location of the CD, this information is transmitted to the microprocessor from BKSD MISZ which recounts the appropriate separation parameters.

Conclusions: The developed microprocessor control unit MISZ Provides NS separation in certain directions with the necessary initial velocities. It is simple to implement, low cost, modular design allows placing it directly in the separation system.

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