Passive Magnetic Stabilization of the Rotational Motion of the Satellite in its Inclined Orbit

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Abstract

The problem of perturbed rotational motion of the satellite is one of the most interesting, important and, at the same time, mathematically complex problems of celestial mechanics and space flight dynamics. Among existing stabilization systems, a passive magnetic stabilization systems have a special place, since they have an exceptional reliability and are easy to manufacture. In this paper the problem of passive magnetic stabilization of the rotational motion of the satellite is studied. It is assumed that passive magnetic system provides its orientation along the vector of the geomagnetic field strength $\vec{H}$. The geomagnetic field is simulated by the direct dipole model, considering different orbits of inclination. In the considered model an effect of the gravitational torque is taken into account. Results of computational experiments are presented.

Keywords: Passive magnetic stabilization, rotational motion, direct dipole model, orbit of inclination, coupled system of differential equations, numerical solution

1 Introduction

Passive Magnetic Stabilization (PMS) is a most used stabilization technique to stabilize small satellites, occupied an inclined orbit around the Earth, by using a combination of strong permanent magnets and hysteresis material.
PMS technique allows the satellite to stabilize by keeping one axis of the spacecraft aligned with the field lines of the Earth magnetic field in orbit. It is expected that perturbation torques tending to produce turning moments about the center of mass of an orbiting satellite will arise from many different causes. Among the more important are the gravitational torque, i.e., torque due to the Earth’s gravitational field, and magnetic torque, i.e., the torque due to the electric and magnetic fields around the Earth. As it was shown in [5] the gravitational torque is the major disturbance torque and exceeds the next largest disturbance, i.e., magnetic torque, by a factor of 6. For this reason, in the considered mathematical model PMS technique is used by taking into account the effect of the gravitational torque. This model has been announced in [12].

The effect of perturbation torques on a satellite’s attitude depends upon the reference frame chosen; the space-stabilized vehicle will be subject to a turning moment due to the variation of the Earth’s gravitational field over the satellite configuration, unless the satellite is a homogeneous sphere for example, when the perturbation torque vanishes. On the other hand an earth-pointing satellite can utilize this gravitational torque as a stabilizing effect, so as to provide a natural position of equilibrium. For small angular displacements from the equilibrium position of an earth-pointing satellite employing reaction-flywheel damping, governing equations of motion have been given in [6].

During the last decades the small satellites have played an important role in the technological development. The attractive short period of design and low cost of them and the capacity to solve problems that are usually considered as problems to big and expensive spacecrafts lead us to study the control problem of these satellites. Active three-axis magnetic attitude stabilization of a low Earth orbit satellite is considered in [8]. The control is created by interaction between the magnetic moment generated by magnetorquers mounted on the satellite body and the geomagnetic field. This problem is quite complex and difficult to solve. Stabilization as a control problem for a satellite is considered in [4], where the control is carried out by a magnetic moment of current coils (magnetorquers) mounted on the satellite body. The stabilizer constructed in this work solves the problems of magnetic and gravitational stabilization. Review of stabilization techniques, in particular, gravity gradient stabilization technique, as the simplest of the three stabilization techniques, is discussed in [11]. Analytical models and some exact solutions of the problem of passive magnetic stabilization related to mathematical models of rotational motion of the satellite has been derived in [2]. Using nonlinear models of hysteresis behavior and nonlinear model of spacecraft attitude dynamics, the problems related to design and analysis of passive stabilization have been considered in [7]. Here some results of nonlinear and quaternions-based mathematical model for satellite motion involving permanent magnets and hysteresis effects
are presented. In [9] an analytical model for the passive magnetically controlled attitude dynamics of the RAX nanosatellite is analyzed. Some with numerical simulations are derived to assess the properties of the attitude dynamics.

In this paper we discuss the problem of passive magnetic stabilization of the rotational motion of the satellite. The effect of the gravitational torque on this stabilization is taken into account. In Section 1 we derive the mathematical model and formulation of the considered problem. Derivation of the electric and the magnetic fields are given in Section 2. In Section 3, a computational analysis of rotational motion of the satellite in its inclined orbit, based on the proposed mathematical model, is explained. Some important conclusions are given in the final Section 4.

2 The mathematical model and problem formulation

The problem of passive magnetic stabilization of the rotational motion of the satellite is studied. Is taken into account the effect of the gravitational torque on passive magnetic stabilization. In the present mathematical model we will discuss the rotational motion during the period of its flight along rotational motion of a satellite during the period \((0, T_f)\) of flight along its inclined orbit around the Earth’s center, and shall base the discussion on Euler’s equations of motion for the rotation of a rigid body around its center of mass. Different from previously considered works, we assume that the body of the satellite is supposed to be non-symmetrical which means, in particular, that the components \(J_{\bar{x}}, J_{\bar{y}}\) and \(J_{\bar{z}}\) of principal moment of inertia are arbitrary. To determine the satellite attitude in space we use the following reference frames. \(O_a\bar{X}\bar{Y}\bar{Z}\) is the geocentric reference frame, \(O_a\) is the Earth center, \(O_a\bar{Y}\) axis is directed along the Earth spin axis, \(O_a\bar{Z}\) lies in the Earth equatorial plane and is directed to the point of the Vernal Equinox, \(O_a\bar{X}\) axis is directed so the system to be a right-handed. \(Oxyz\) is the orbital reference frame, \(O\) is the satellite center, \(Oy\) lies in the orbital plane, is perpendicular to the radius vector and directed as the orbital velocity does, \(Oz\) axis is directed along the radius-vector of a satellite, \(Ox\) is directed such that the reference frame is right-handed. \(O\bar{x}\bar{y}\bar{z}\) is the moving reference system, its axes are directed along the principal axes of inertia of the satellite. We will define the attitude of the moving reference system \(O\bar{x}\bar{y}\bar{z}\) with respect to the orbital reference frame \(Oxyz\) via the angles \(\Psi, \Theta\) and \(\Phi\).

The mutual orientations of these reference frames are determined by the
following linear transformations with direction cosine matrices:

\[
\begin{pmatrix}
  x \\
y \\
z
\end{pmatrix} = \begin{pmatrix}
  \alpha_1 & \alpha_2 & \alpha_3 \\
  \beta_1 & \beta_2 & \beta_3 \\
  \gamma_1 & \gamma_2 & \gamma_3
\end{pmatrix} \begin{pmatrix}
  \bar{x} \\
  \bar{y} \\
  \bar{z}
\end{pmatrix} = \begin{pmatrix}
  a_1 & a_2 & a_3 \\
  b_1 & b_2 & b_3 \\
  c_1 & c_2 & c_3
\end{pmatrix} \begin{pmatrix}
  x \\
y \\
z
\end{pmatrix}
\] (2.1)

Let \( u = \omega_\pi + \nu \) be the argument latitude, \( \omega_\pi \) be the argument of periapsis, \( \nu \) be the true anomaly, \( i \) be the orbit inclination and \( \Omega \) be longitude of the ascending node of the orbit from the point of the Vernal Equinox. We will use the following relationships between the direction cosines, the angles \( \Phi, \Psi, \Theta \), and the above defined parameters [1]:

\[
\begin{align*}
\alpha_1 &= \cos \Theta \cos \Phi, \\
\alpha_2 &= -\cos \Theta \sin \Phi, \\
\alpha_3 &= \sin \Theta, \\
\beta_1 &= \cos \Psi \sin \Phi + \sin \Psi \sin \Theta \cos \Phi, \\
\beta_2 &= \cos \Psi \cos \Phi - \sin \Psi \sin \Theta \sin \Phi, \\
\beta_3 &= -\sin \Psi \cos \Theta, \\
\gamma_1 &= \sin \Psi \sin \Phi - \cos \Psi \sin \Theta \cos \Phi, \\
\gamma_2 &= \sin \Psi \cos \Phi + \cos \Psi \sin \Theta \sin \Phi, \\
\gamma_3 &= \cos \Phi \cos \Theta.
\end{align*}
\] (2.2)

The dynamic and kinematic equations of the angular motion of the satellite in an inclined orbit is described by

\[
\begin{align*}
J_\beta \ddot{\beta} + (J_\gamma - J_\beta)\dot{q}r &= M_{m\beta} + M_{g\beta}, \\
J_\gamma \ddot{q} + (J_\beta - J_\gamma)\dot{p}r &= M_{m\gamma} + M_{g\gamma}, \\
J_\beta \dot{r} + (J_\gamma - J_\beta)\dot{pq} &= M_{m\beta} + M_{g\beta}, \\
p(0) &= p_0; \quad q(0) = q_0; \quad r(0) = r_0.
\end{align*}
\] (2.3)

\[
\begin{align*}
\dot{\Phi} &= p - (q \cos \Phi - r \sin \Phi) \tan \Theta - \frac{\sin \Psi}{\cos \Theta} \frac{\omega_0}{(1 - e^2)^{3/2}} (1 + e \cos \nu)^2, \\
\dot{\Psi} &= \frac{(q \cos \Phi - r \sin \Phi)}{\cos \Theta} + \sin \Psi \tan \Theta \frac{\omega_0}{(1 - e^2)^{3/2}} (1 + e \cos \nu)^2, \\
\dot{\Theta} &= q \sin \Phi + r \cos \Phi + \frac{\omega_0}{(1 - e^2)^{3/2}} (1 + e \cos \nu)^2, \quad t \in (0, T_f), \\
\Phi(0) &= \Phi_0; \quad \Psi(0) = \Psi_0; \quad \Theta(0) = \Theta_0.
\end{align*}
\] (2.4)

Here \( p, q \) and \( r \) are the projections of the satellite’s angular velocity onto the axis of the moving reference system \( O\bar{x}\bar{y}\bar{z} \). Further, \( M_m := (M_{m\beta}, M_{m\gamma}, M_{m\beta})^T \) and \( M_g := (M_{g\beta}, M_{g\gamma}, M_{g\beta})^T \) are the magnetic and gravitational moments, respectively, \( \omega_0 \) is the angular velocity of the orbital motion and \( e \) is the eccentricity.

Note that in the considered mathematical model not only each system of differential equations (2.3) and (2.4) are the coupled system, but also the
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system (2.3)-(2.4) is also a coupled one. The system of dynamic equations (2.3) has previously been studied by several authors assuming various symmetry conditions. In the presented mathematical model, we investigate the coupled system of dynamic and kinematic equations (2.3)-(2.4) not only in its general form, but also assume that the function \( \nu = \nu(t) \) in (2.3)-(2.4) is not a given data, but is a solution of the Cauchy problem for the following differential equation:

\[
\begin{align*}
\dot{\nu} &= \frac{\omega_0}{(1 - e^2)^{3/2}} (1 + \epsilon \cos \nu)^2, \quad t \in (0, T_f) \\
\nu(0) &= \nu_0.
\end{align*}
\] (2.5)

Therefore one of goals of the study is to solve the coupled system of differential equations (2.3)-(2.4) with respect to the unknown angles \( \Phi, \Psi, \Theta \), and the projections \( p, q \) and \( r \) of the satellite's angular velocity, taking into account that the true anomaly function of time \( \nu = \nu(t) \) is the solution of the Cauchy problem (2.5). The magnetic and gravitational moments \( M_m := (M_{mx}, M_{my}, M_{mz})^T \) and \( M_g := (M_{gx}, M_{gy}, M_{gz})^T \) in (2.3) will be calculated analytically.

3 Derivation of the electric and the magnetic fields

According to the mathematical theory of magnetic field of Earth, the potential of the internal geomagnetic field \( U_m \) which varies inversely with the distance from the center of the Earth to a point in space, is represented by the following series spherical harmonics (see [10]):

\[
U_m = \sum_{n=1}^{\infty} \left( \frac{R_n}{R_{n+1}} \right) \sum_{m=0}^{\infty} P^m_n \cos(m\lambda_R) \left( g^m_n \cos(m\lambda_R) + h^m_n \sin(m\lambda_R) \right).
\] (3.1)

Here \( R_e > 0 \) is the mean equatorial radius of the Earth, \( R, \lambda_R, \theta_R \) are the spherical coordinates of the satellite in the space where the potential is calculated (\( R \) is the radius-vector of the satellite, \( \lambda_R \) is the geographical longitude and \( \theta \) is the angle between the radius-vector and the spin axis of the Earth), \( P^m_n \) is the associate Legendre function of the first kind of degree \( n \) and order \( m \), \( g^m_n \) and \( h^m_n \) are the Gaussian coefficients. Then the vector of geomagnetic field strength with potential (3.1) is defined as follows

\[
\vec{H} = -\nabla U_m.
\]

As numerous measurements the Earth’s magnetic field on the surface of the globe, as well as near-Earth space show, in the first approximation, the
Earth’s magnetic field close to the field of a uniformly magnetized sphere or field of a dipole placed in the center of the Earth, with the North Magnetic Pole corresponding to the South Geographic Pole and vice versa. In view of this approximate model, certain terms of the series (3.1) have precise physical interpretations. Let us consider those terms used in the investigation of satellite dynamics under the effect of the geomagnetic field. If we take into consideration the coefficient \( g_1^0 \) only \((n = 1, m = 0)\), the field described by the series (3.1) is the field of a dipole situated at the center of the Earth and oriented antiparallel to its spin axis, i.e. oriented in the direction North to South. This is the, so called, direct dipole model. This model is able to take into account the two principle features of the behavior of the local vector \( \vec{H} \) of magnetic field strength during the motion of a satellite along its orbit, namely, non-uniform rotation of \( \vec{H} \) with respect to the inertial reference system and variations in its magnitude.

According to the dipole field the vector \( \vec{H} \) can be represented as follows [1]:

\[
\vec{H} = \mu_e \left\{ \vec{k}_E - 3(\vec{k}_E \vec{e}_R) \vec{e}_R \right\} / R^3,
\]

where \( \mu_e \) is the Earth’s magnetic moment, \( \vec{k}_E \) is the unit vector of the dipole axis, \( \vec{e}_R \) is the unit vector in the direction of the radius-vector. By means of projections of this vector on the geocentric reference system \( O_a \bar{X} \bar{Y} \bar{Z} \) this yields:

\[
H_{\bar{X}} = -\frac{3 \mu_e}{R^3} \sin i \cos i \sin^2 u, \quad H_{\bar{Y}} = -\frac{3 \mu_e}{R^3} (1 - 3 \sin^2 i \sin^2 u), \quad H_{\bar{Z}} = \frac{\mu_e}{R^3} \sin i \sin u \cos u
\]

(3.2)

Let us consider the simplest practical method of realizing passive satellite stabilization. This involves providing orientation along the vector \( \vec{H} \) of the local geomagnetic field strength. In this case, a restoring magnetic torque, arise from the interaction between a permanent magnet installed on-board the satellite and the local geomagnetic field. The magnetic moment of the magnet is chosen to be sufficiently strong to govern the motion of the satellite with respect to the vector \( \vec{H} \). Within the framework of the direct dipole, the magnetic torque is defined as follows:

\[
\vec{M}_m = \vec{I}_0 \times \vec{H}.
\]

Here the vector \( \vec{I}_0 = (I_{0x}, I_{0y}, I_{0z})^T \) is the magnetic moment of the satellite. Note that this moment arises due to the permanent magnet on board. Then using (2.1) and (2.2) in (3.2), after simple calculations, we find the coordinates \( H_{\bar{x}}, H_{\bar{z}}, H_{\bar{z}} \), of
the geomagnetic field strength vector $\vec{H}$ in the moving reference system $O\bar{x}\bar{y}\bar{z}$:

$$H_x = \frac{\mu_c}{R^3} \{ (3 \cos i \cos \Omega \sin^3 u - 3 \cos^2 u \cos \Omega \sin u + \sin \Omega - 3 \sin^2 i \sin^2 u \sin \Omega + 6 \cos^2(i/2) \cos i \cos u \sin^2 u \sin \Omega) \sin \Theta + [(3(1 + \cos i) \cos u \sin i \sin u - 1 + 3 \sin^2 i \sin^2 u) \sin \Phi \sin u - [(1 + 3 \cos i \cos u \sin^2 u + 3 \cos^2 i \cos u \sin^2 u - 3 \sin^2 i \sin^2 u) \cos \Omega - 3(\cos^2 u + \cos i \sin^2 u) \sin u \sin \Omega] \cos \Phi] \cos \Theta \} \sin i,$$

$$H_y = \frac{\mu_c}{R^3} \{ (\cos \Psi \sin \Phi + \cos \Phi \sin \Theta \sin \Psi)[3(\cos^2 u + \cos i \sin^2 u) \sin u \sin \Omega - (1 + 3 \cos i \cos u \sin^2 u + 3 \cos^2 i \cos u \sin^2 u - 3 \sin^2 i \sin^2 u) \cos \Omega - (\cos \Phi \cos \Psi + \sin \Phi \sin \Theta \sin \Psi)(3(1 + \cos i) \cos u \sin i \sin u - 1 + 3 \sin^2 i \sin^2 u) \sin u + [3 \cos^2 u \cos \Omega \sin u - 3 \cos i \cos \Omega \sin^3 u - 6 \cos^2(i/2) \cos i \cos u \sin^2 u \sin \Omega + (3 \sin^2 i \sin^2 u - 1) \sin \Omega] \cos \Theta \sin \Psi \} \sin i,$$

$$H_z = \frac{\mu_c}{R^3} \{ 3(\cos \Theta \cos \Psi \cos \Omega + (\sin \Phi \sin \Psi - \cos \Phi \cos \Psi \sin \Theta) \sin \Omega) \cos i \sin^3 u - 3[\cos \Theta \cos \Psi \cos \Omega + (\cos \Phi \cos \Psi \sin \Theta - \sin \Phi \sin \Psi) \sin \Omega] \cos^2 u \sin u + (3 \sin^2 i \sin^2 u - 1)[(\cos \Psi \cos \Omega \sin \Theta + \sin u \sin \Psi) \cos \Phi - \cos \Omega \sin \Phi \sin \Psi + (\sin u \sin \Theta \sin \Phi + \cos \Theta \sin \Omega) \cos \Psi] + (3(1 + \cos i) [(\cos \Phi \cos \Psi \cos \Omega \sin \Theta - \cos \Omega \sin \Phi \sin \Psi + \cos \Theta \cos \Psi \sin \Omega) \cos i - (\cos \Psi \sin \Theta \sin \Phi + \cos \Phi \sin \Psi) \sin i] \cos u \sin^2 u \} \sin i.$$

We assume that the vector $\vec{I}_0$ is located along the $O\bar{z}$ axis, i.e. $\vec{I}_0 := (0, 0, I_0)^T$. Then for the projections $M_{m\bar{x}}, M_{m\bar{y}}, M_{m\bar{z}}$, of the magnetic torque $\vec{M}_m = \vec{I}_0 \times \vec{H}$ of the Earth we have: $M_{m\bar{x}} = -I_0 H_y$, $M_{m\bar{y}} = I_0 H_z$, $M_{m\bar{z}} = 0$.

Using (3.3) we obtain:

$$M_{m\bar{x}} = -\frac{I_0 \mu_c}{R^3} \{ (\cos \Psi \sin \Phi + \cos \Phi \sin \Theta \sin \Psi)[3(\cos^2 u + \cos i \sin^2 u) \sin u \sin \Omega - (1 + 3 \cos i \cos u \sin^2 u + 3 \cos^2 i \cos u \sin^2 u - 3 \sin^2 i \sin^2 u) \cos \Omega + \sin \Phi \sin \Theta \sin \Psi)(3(1 + \cos i) \cos u \sin i \sin u - 1 + 3 \sin^2 i \sin^2 u) \sin u + [3 \cos^2 u \cos \Omega \sin u - 3 \cos i \cos \Omega \sin^3 u - 6 \cos^2(i/2) \cos i \cos u \sin^2 u \sin \Omega + (3 \sin^2 i \sin^2 u - 1) \sin \Omega] \cos \Theta \sin \Psi \} \sin i,$$

$$M_{m\bar{y}} = \frac{I_0 \mu_c}{R^3} \{ (3 \cos i \cos \Omega \sin^3 u - 3 \cos^2 u \cos \Omega \sin u + \sin \Omega - 3 \sin^2 i \sin^2 u \sin \Omega + 6 \cos^2(i/2) \cos i \cos u \sin^2 u \sin \Omega) \sin \Theta + [(3(1 + \cos i) \cos u \sin i \sin u - 1 + 3 \sin^2 i \sin^2 u) \sin \Phi \sin u - [(1 + 3 \cos i \cos u \sin^2 u + 3 \cos^2 i \cos u \sin^2 u - 3 \sin^2 i \sin^2 u) \cos \Omega - 3(\cos^2 u + \cos i \sin^2 u) \sin u \sin \Omega] \cos \Phi] \cos \Theta \} \sin i,$$

$$M_{m\bar{z}} = 0.$$

Formulas (3.4) will be used below in our computational experiments.

The disturbing torque $\vec{M}_g = (M_{g\bar{x}}, M_{g\bar{y}}, M_{g\bar{z}})^T$ produced by the gravita-
Figure 1: Behavior of the projection $p(t)$ of the satellite’s angular velocity for orbit inclinations $i = 0^\circ; 15^\circ; 30^\circ; 45^\circ; 60^\circ; 75^\circ$.

4 Computational analysis of rotational motion of the satellite in its inclined orbit

This section deals with the numerical solution of the coupled system of differential equations (2.3)-(2.5). We will use here the fourth-order explicit Runge-Kutta method, which is popular as each stage can be calculated with one function evaluation (see, for example, [3]). For this aim this method first is applied...
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Figure 2: Behavior of the projections $q(t)$ and $r(t)$ of the satellite’s angular velocity for orbit inclinations $i = 0^\circ; 45^\circ; 75^\circ$.

to the Cauchy problem (2.5) for funding numerical values of the true anomaly function $\nu(t)$. Then these values are used in the coupled system (2.3)-(2.4). To show the algorithm of the Runge-Kutta method, we rewrite the coupled system (2.3)-(2.4) in the vector form, introducing the vector $\mathcal{V} := (p, q, r, \Phi, \Psi, \Theta)^T$, $\mathcal{V} = \mathcal{V}(t)$:

$$
\begin{align*}
\dot{\mathcal{V}} &= \mathcal{F}_i(\mathcal{V}, t), \ i = 1, 6, \\
\mathcal{V}(0) &= \mathcal{V}_0, \ \mathcal{V}_0 = (p_0, q_0, r_0, \Phi_0, \Psi_0, \Theta_0)^T.
\end{align*}
$$

(4.1)

We apply the second order accurate midpoint Runge-Kutta method, using the derivative at the initial time $t = t_0$, to approximate the derivative at the time midpoint $t_{j+1/2} := t_j + \tau/2$ of the uniform time mesh $\omega_\tau := \{t_j \in [0, T_f] : t_j = j\tau, \ \tau = T_f/J\}$:

$$
\begin{align*}
K_1 &= \tau \mathcal{F}_i(\mathcal{V}_j, t_j), \ K_2 = \tau \mathcal{F}_i(\mathcal{V}_j + K_1/2, t_j + h/2), \\
\mathcal{V}_{j+1} &= \mathcal{V}_j + K_2, \ j = 0, J.
\end{align*}
$$

(4.2)

The results of computational experiments are shown in Fig. 1-3. Specifically, Figures 1 illustrate the behavior of the projection $p(t)$ of the satellite’s angular velocity onto the axis of the moving reference system $Ox$. The first figure, corresponding to the inclination $i = 0^\circ$, show that stabilization of the
Figure 3: The values \( p(t_i) \), \( q(t_i) \) and \( r(t_i) \) of the projections \( p(t) \), \( q(t) \) and \( r(t) \), depending on the orbit inclination \( i \), at the times \( t_1 = 1.0 \times 10^2 \), \( t_2 = 1.0 \times 10^4 \), \( t_3 = 5.0 \times 10^4 \), \( t_4 = 7.5 \times 10^4 \).

angular velocity occurs when \( t > 2.0 \times 10^4 \). The reason is that for equatorial orbit the strength vector \( \vec{H} \) remains constant at all points of orbit and is orthogonal to the orbital plane. For other orbits of inclinations over 15\(^\circ\), Passive Magnetic Stabilization is not effective to stabilize small satellites, as next figures show. Similar effects are observed from Figure 2. The values \( p(t_i) \), \( q(t_i) \) and \( r(t_i) \) of the projections of the angular velocity, depending on the orbit inclination \( i \), at the initial (\( t_1 = 1.0 \times 10^2 \)), middle (\( t_2 = 1.0 \times 10^4 \), \( t_3 = 5.0 \times 10^4 \)) and close to the final (\( t_4 = 7.5 \times 10^4 \)) times are plotted in Figure 3.

5 Conclusions

During the rotational motion of the satellite along its orbit, the magnitude and direction of the vector of the geomagnetic field strength \( \vec{H} \) is varying. This makes impossible to make a satellite’s orientation as desired. The systematic perturbations can cause oscillations of a satellite near the resonance frequency. In this paper direct dipole model of the Earth’s magnetic field governed by the coupled system of differential equations (2.3)-(2.5) is considered. The problem of passive magnetic stabilization of the rotational motion of the satellite is studied by taking into account the effect of the gravitational torque on this stabilization. An analysis of obtained numerical results show that as the satellite orbit tends to be polar (with an inclination of exactly 90\(^\circ\)), an influence of the geomagnetic field increases, since the strength vector \( \vec{H} \) varies at each point of the satellite’s orbit. It is shown that for near equatorial orbits of inclinations under 10\(^\circ\), Passive Magnetic Stabilization is most effective to stabilize small satellites. However, this technique is not enough effective for satellite’s orbits
with an inclination of more $10^\circ$. In order to achieve desired stabilization, one needs to take into account damping moments. This issue will be subject of next study.

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