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Research Article

A Two-Dimensional Solar Tracking Stationary Guidance Method Based on Feature-Based Time Series

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The amount of satellite energy acquired has a direct impact on operational capacities of the satellite. As for practical high functional density microsatellites, solar tracking guidance design of solar panels plays an extremely important role. Targeted at stationary tracking problems incurred in a new system that utilizes panels mounted in the two-dimensional turntable to acquire energies to the greatest extent, a two-dimensional solar tracking stationary guidance method based on feature-based time series was proposed under the constraint of limited satellite attitude coupling control capability. By analyzing solar vector variation characteristics within an orbit period and solar vector changes within the whole life cycle, such a method could be adopted to establish a two-dimensional solar tracking guidance model based on the feature-based time series to realize automatic switching of feature-based time series and stationary guidance under the circumstance of different β angles and the maximum angular velocity control, which was applicable to near-earth orbits of all orbital inclination. It was employed to design a two-dimensional solar tracking stationary guidance system, and a mathematical simulation for guidance performance was carried out in diverse conditions under the background of in-orbit application. The simulation results show that the solar tracking accuracy of two-dimensional stationary guidance reaches 10° and below under the integrated constraints, which meet engineering application requirements.

1. Introduction

As microsatellites are featured with being light, small, smart, and cheap, they not only have become the research hotspot of satellite technology development and application, but are growing towards a direction of high functional density and practical applications. In order to adapt to multitype tasks and diversified applications, the requirement for higher payload power appropriate for high functional density microsatellites has been increasingly intense for the consideration of higher cost performance, rapid deployment, and extensive applicability. However, energy maximization must be taken into account with an aim to make microsatellites applied in high-power loads. Specific to application characteristics of microsatellites cluster or network, the scheme of energy maximization should be universal. Especially for the typical nonsolar synchronous inclined orbits such as Globalstar system, the solar panels adopting a solar tracking revolving mechanism is the only approach to solving energy acquisition issues provided that the platform itself remains an earth-oriented demand.

In order to maximize the output power improving the efficiency, many methods and devices of sun tracking and maximum power point tracking were proposed, which belong to the special issue of solar energy application in ground photovoltaic systems. There are some fuzzy techniques that were proposed in photovoltaic systems [1–3], such as a method based on simultaneous use of two fuzzy controllers in order to maximize the generated output power of a solar panel. The sun tracking is performed by changing the solar panel orientation in horizontal and vertical directions by two DC motors properly designed. Several solutions for two axis solar tracking systems based on solar maps or based on tetrahedron geometry were studied, which can predict the exact apparent position of the sun or the strongest intensity of visible light [4–6]. Dual-axis solar tracking design utilizes a four-quadrant light dependent resistor (LDR) sensor or adaptive solar sensor and so on. The control of moving the mechanical structure uses a low power microcontroller or a traditional PLC [7–10].

For satellite, the maximum energy acquisition purpose is the same that is achieved generally by solar array drive assembly (SADA). As the microsatellites pursue a high performance-price ratio strictly limiting development costs, it is impossible to select expensive SADA with slip ring. The light-small two-dimensional turntable could be used to carry the solar panels to realize solar tracking. For the convenience of open-loop control, stepping motor was utilized as a drive element. Nevertheless, the stepping motor still has some shortcomings such as poor dynamic behavior, high pulse step overshoot, and great rate ripple, and it is a nonnegligible interference source as far as satellites with a high requirement for attitude stabilization, such as earth observation satellites. Now, satellite rotating mechanism has been extensively investigated at home and abroad, covering mechanism models, ground-based validation, controller design, and attitude control coupling [11–14].

Solving the problem related to rotating mechanism motion stability of solar panels is a key to guaranteeing high pointing accuracy and high attitude stabilization of satellites. Factors that affect rotating mechanism motion stability can be elaborated from the following two aspects. Firstly, cogging torque of the stepping motor leads to instability of control, which can be resolved by means of compensation, and research on this issue has been relatively mature. SPOT satellite of France adopts a great subdivision sine/cosine driving strategy and an accelerometer to measure perturbed moment and implement compensation [15]. Engineers of NASA also introduce an input molding technique [16]. Additionally, an adaptive uniaxial driving strategy based on current compensation has been explored [17]. Secondly, due to instability of input angular velocity guiding turntable motion, the accurate angular velocity in the case of two-dimensional solar tracking becomes unstable. However, such an issue is usually neglected under the circumstance of unlimited capacity so that relevant investigations can be rarely seen as well.

A solar tracking stationary guidance method based on feature-based time series was proposed under the background of microsatellite solar panels loaded with two-dimensional turntable. Through phase division for time within an orbit period, the target velocity was divided into several segments of steady speeds, so as to solve guidance input instability problems and substantially reduce variable speed control. The high-stability and small-disturbance control of the two-dimensional turntable can be fulfilled.

2. Problem Description and Modeling

Concerning a microsatellite that adopts orbital inclination of 55°, β angle (the included angle between solar vector and orbital plane) varies between $+78^\circ$ and -78°. Simultaneously, the corresponding tasks request the satellite to remain earth-oriented.

Specific to the microsatellite characteristics, when β angle is close to $\pm 78^\circ$, the included angle formed by solar vector and normal of the solar panels should be greater than 78° if the conventional one-dimensional SADA has been utilized. In this case, solar panels are deemed to acquire no energy. Considering that the satellite runs in a 55° inclined orbit, such a phenomenon exists within a period long enough to incur unbalanced satellite energy supply making the entire satellite unable to run normally. Resultantly, two-dimensional rotation must be conducted to realize solar tracking orientation of the panels under the circumstance that earth-oriented status of the satellite is maintained, which is able to maximize energy acquired. As the two-dimensional turntable is employed, 360-degree continuous rotation cannot be completed; thus an appropriate two-dimensional solar tracking stationary guidance strategy should be formed to guarantee that the satellite can acquire enough energies for operation in a condition of different β angles.

2.1. Basic Assumption. The two-dimensional turntable mechanism makes use of a stepping motor. Without loss of generality, friction moment, fluctuating moment, cogging torque, and mechanism dynamics were taken into account, while mutual induction winding, high-order harmonic torque, and external disturbance torque of the motor were ignored. Based on a cogging moment compensation method, velocity stability of the turntable could be improved. In addition, it has been assumed that the angular velocity of the turntable can be matched with the guidance input.

2.2. Constraint Condition

2.2.1. Two-Dimensional Rotation Angle Limitation Constraint. With regard to the microsatellite, area of its solar panels unfolded is very large so that it is able to occlude payload or sensor field of view of its planes $\pm x$ and $\pm y$. The maximum rotation angle of solar panels defined according to structural configuration and field of view requirements for satellites can be denoted by α_{MAX}. In this case, principal axis of the solar panels (normal direction of the panel) is only able to rotate within a circular cone of semi-cone angle α_{MAX} that adopts the satellites radius vector (i.e., the earth's core points at the satellite) as its axis. Furthermore, the value of α_{MAX} was defined to be 90° dependent on physical design outcomes.

2.2.2. Attitude Control Capacity Constraint. Due to the influence of the capacity possessed by an actuator selected for the microsatellite, the maximum angular velocity and the maximum angular acceleration of the turntable should be no more than $0.2^\circ/\mathrm{s}$ and $0.01^\circ/\mathrm{s}^2$, respectively, for the purpose of ensuring that disturbance to the platform during turntable running satisfies the earth-oriented stabilization control requirement.

2.2.3. Pointing Error Constraint. Within the range of limited maximum rotation angle denoted as α_{MAX}, angle tracking error of solar tracking should be no more than $14^\circ(\cos 14^\circ =$

0.970) to guarantee that the amount of energy acquired can be maximized.

2.3. Model Input. S_o refers to a normalized solar vector in an orbital coordinate system.

Not only can solar vector be acquired by an on-board sun sensor or obtained through calculations based on sun ephemeris, but its expression in an orbital coordinate system is obtained in line with an attitude transformation relation.

T_{sec} stands for on-board cumulative seconds relative to on-board starting time.

2.4. Model Output. In conformity with input and constraint conditions, feature-based time series and angle/angular velocity series required by turntable control can be autonomously calculated to form target angles and angular velocities controlling the turntable in diverse time points. These series consist of pitching direction control time series T_{θ_Guide}, azimuth direction control time series T_{ψ_Guide}, pitching angular velocity series $\omega_{\theta\_\text{Guide}}$, and azimuth angular velocity series $\omega_{\psi\_\text{Guide}}$. The corresponding output model can be expressed in

$$\begin{gathered}\left[T_{\theta\_\text{Guide}}, T_{\psi\_\text{Guide}}\right] = f\left(S_o, T_{\text{sec}}\right), \\ \left[\omega_{\theta_{\text{Guide}}}, \omega_{\psi_{\text{Guide}}}\right] = g\left(T_{\theta_{\text{Guide}}}, T_{\psi_{\text{Guide}}}\right).\end{gathered} \tag{1}$$

3. Guidance Law Design

Time series is a set of variables ordered chronically and the solar tracking angular relation can be described by multiple time series in one orbit. Therefore, characteristic time points should be selected to form time series for guidance implementation. Then, guidance requirement of the specified accuracy is fulfilled through density control over the series.

Design purpose of the two-dimensional solar tracking stationary guidance law is to guarantee maximization of energies acquired by the solar panels under constraints.

3.1. Optimal Pointing Guidance Law in Angle Limitation Constraint. Under constraint described in Section 2, that is, in a condition of two-dimensional rotation angle limitation, conical surface formed by the maximum limited angle constituted by the principal axis of solar panels intersects with that formed by rotation of the sun around orbital plane normal of the satellite. Optimal pointing of the solar panels principal axis is the combination of two segments of arcs, as shown in Figure 1. In general cases, two conical surfaces mentioned above directly intersect with each other or intersect in a translation manner among the conical surfaces, as points 1–4 presented in Figure 1.

When the satellite is in a light region, solar tracking guidance strategy of the panels can be illustrated as follows. On one hand, while the solar vector is within a constrained conical plane formed by the maximum rotation angle of the solar panels principal axis, the panel can track the sun, which is referred to as sun-oriented; on the other hand, if the solar vector is outside the constrained conical plane described

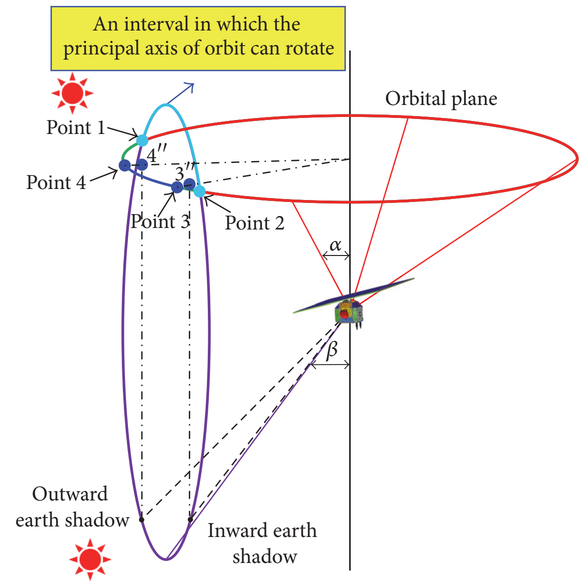

Figure 1: A schematic diagram of solar panels optimal pointing under constraints.

above, solar panels can track projection of the solar vector on the conical plane, which is known as quasi-sun-oriented.

When the satellite is in a shadow region, solar tracking of panels principal axis has no significance. Considering this, only a guidance strategy of "rotating to the symmetric position in constant speed via the shortest path" is proposed. In other words, when the satellite is in a shadow region, rotating mechanism of the solar panels rotates its principal axis to the pointing at the moment of moving out of the shadow region from that when it moves into the shadow region along the shortest path. As azimuth pointing of the solar panels entering or exiting the shadow region is the complementary opposite number and the pointing and their pitch angle are identical, they are called symmetric positions.

By analyzing different temporal intervals, the included angle between sun pointing and zenith direction is the target attitude angle θ. In addition, the maximum included angle formed by panel pointing and the zenith direction is the limited angle α_{MAX}. As for the target attitude angle of demarcation points distinguishing shadow and light, it is denoted by γ representing earth shielding angle. Then, the following conclusions can be drawn.

Point 1 to 2, the light region, $|\theta| \le \alpha_{\text{MAX}}$: the solar vector is located in the range of solar panels' maximum rotation angle, which indicates that the panel points at the solar vector.

Point 2 to 3, the light region, $\alpha_{\text{MAX}} \le |\theta| \le \gamma$: solar panels point at projection of the solar vector in the conical plane of the maximum rotation angle.

Point 3 to 4, the shadow region, $|\theta| \ge \gamma$: the panel rotates to the pitch symmetrical attitude at a uniform velocity along the shortest path.

Point 4 to 1, the light region, $\alpha_{\text{MAX}} \le |\theta| \le \gamma$: the panel points at the projection of solar vector in the conical plane of the maximum rotation angle.

To sum up, solar tracking guidance strategy of panels can be concluded as follows.

If $|\theta| \leq \alpha_{\mathrm{MAX}}$, sun-oriented mode can be established.

If $\alpha_{\mathrm{MAX}} \leq |\theta| \leq \gamma$, projection axis-oriented mode can be established.

If $|\theta| \geq \gamma$, it rotates to the symmetrical position at a uniform velocity along the shortest path.

3.2. Two-Dimensional Solar Panel Guidance Law in a Synthetic Constraint Condition. Subjected to synthetic constraint conditions described in Section 2, azimuth angular velocities are very high (see simulation results in Section 4) in terms of azimuth-elevation type turntables when β angle is rather small. It fails to satisfy torque requirement of attitude control disturbances. Therefore, only rotation in pitching direction is conducted under the circumstance that β angle is small. As for large and small β angles, the pattern partition strategy is utilized to carry out independent guidance.

According to the constraint of angle tracking error should be no more than 14° described in Section 2, in order to retain a certain allowance, and $|\beta|$ below 10° is defined as small β angle, while that greater than or equal to 10° is defined as large β angle. Furthermore, calculation formula of β angle is given below.

$$\beta = \operatorname{asin}\left(S_{oy}\right), \tag{2}$$

where S_{oy} is component of solar vector along direction y in an orbital coordinate system.

To meet relevant synthetic constraint conditions, autonomous switching of feature-based time series was implemented for solar tracking of panels according to large and small β angles for the purpose of performing independent guidance. Within an orbit period, several characteristic time slots were segmented to adjust angular velocities. A two-dimensional rotation mode should be adopted in the case of large β angle to realize two-dimensional feature-based time series guidance. By contrast, if β angle is small, one-dimensional rotation mode was used to conduct one-dimensional feature-based time series guidance.

3.2.1. Large β-Angle Guidance Strategy. The difficulty of the two-dimensional rotation mode lies in constraints over angular velocity and angular acceleration. Besides, it is less likely for azimuth angular velocity across the zenith to meet demands if β angle is small. On this basis, the strategy can be elaborated as follows.

Expression of solar vector in the orbital coordinate system is used to figure out the next time point when the sun moves across zenith of the satellite and the number of characteristic time points within an orbit period. Regarding the latter, it incorporates the maximum angular velocity equilibrium point, the maximum limited angle time point, and the light and shadow region demarcation time point. Then, time of one orbit is divided into several time slots according to characteristic time points to calculate the mean angular velocity under the circumstance that two points on both ends of each time slot remain consistent with the target attitude, to update the time series dependent on the calculated maximum angular acceleration, and to finally output time series and angular velocity series needed by the turntable. Moreover, time slots in the time series can be further segmented by means of dichotomy to increase the number of series subsections, so that angular accuracy in the entire guidance process can be improved.

As regards characteristic time points in the minimum feature-based time series, they can be computed in the following ways.

(1) Time point T_0 across zenith of the satellite:

$$\begin{aligned} \alpha &= \operatorname{atan2}\left(S_o(1) - S_o(3)\right), \\ T_0 &= T_{\mathrm{sec}} + \alpha \times \frac{T}{2\pi}, \end{aligned} \tag{3}$$

where T refers to orbit period and can be figured out in line with satellite orbit by the following equation:

$$\begin{aligned} T = {} & 2\pi\sqrt{\frac{a^3}{\mu}} \\ & \times \left(1 - 1.5 \times J_2 \times \frac{{R_e}^2}{a^2} \times \left(3 - 4(\sin i)^2\right)\right), \end{aligned} \tag{4}$$

where $R_e = 6378.137\,\mathrm{km}$, $J_2 = 1.08263 \times 10^{-3}$, and $\mu = 3.986004418 \times 10^{+5}$; furthermore, a and i are the semi-major axis and mean elements of orbital inclination.

(2) Maximum angular velocity equilibrium time point T_1: it is calculated by a Newton iteration method and the time function can be written as the following equation.

$$\begin{aligned} f(x) = {} & \left\{\operatorname{atan}\left[\cos\beta \times \frac{\cos(2\pi/T \times x - \pi/2)}{\sin\beta}\right] - 0.99 \right. \\ & \left. \times \omega_{\max} \times x\right\}. \end{aligned} \tag{5}$$

(3) Maximum limited angle time point T_2:

$$T_2 = \operatorname{acos}\left(\frac{\cos(\alpha_{\mathrm{MAX}})}{\cos\beta}\right) \times \frac{T}{2\pi}. \tag{6}$$

(4) Light and shadow region demarcation time point T_3:

$$T_3 = \left(\pi - \operatorname{acos}\left(\frac{\cos\gamma}{\cos\beta}\right)\right) \times \frac{T}{2\pi}. \tag{7}$$

(5) Other time points are calculated by a symmetric method as follows:

$$T_i = T - T_{7-i}, \quad i = 4, 5, 6. \tag{8}$$

Solar panels guidance procedure in a condition of large angle has been shown in Figure 2.

Due to time point calculation error accumulation and that of angular deviation in a condition of angular velocity control, time points in the time series and angular velocities in angular velocity series should be corrected during execution of guidance strategy. While correction of time points was realized by updating covering time, angular velocities were corrected by actual turntable feedback angle recalculations of switching time points.

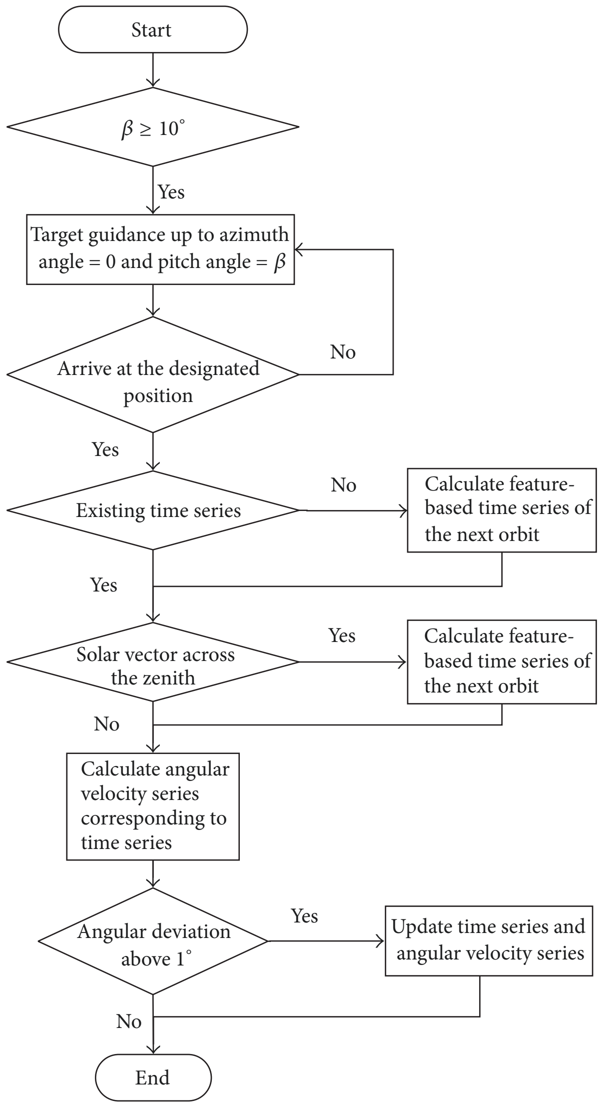

Figure 2: Solar tracking of panels guidance process in the case of large angle.

3.2.2. Small β-Angle Guidance Strategy. Under the circumstance of small β angle, time of an orbit period was divided into four segments according to the light and shadow region demarcation point and limited angle switching point (see Section 3), so as to work out their angular velocities. Moreover, two of such four segments fall into the category of quasi-sun-oriented. In a condition of small β angle, the solar panels guidance procedure is illustrated in Figure 3.

Under the circumstance of one-dimensional rotation, the solar vector rotates within the orbital plane at a uniform velocity. Therefore, the sun-oriented pitch angular velocity can be calculated by the following equation.

$$V_1 = \frac{2\pi}{T}. \quad (9)$$

Angular velocity of the shadow region means going back to the symmetric position within the time slot of this region.

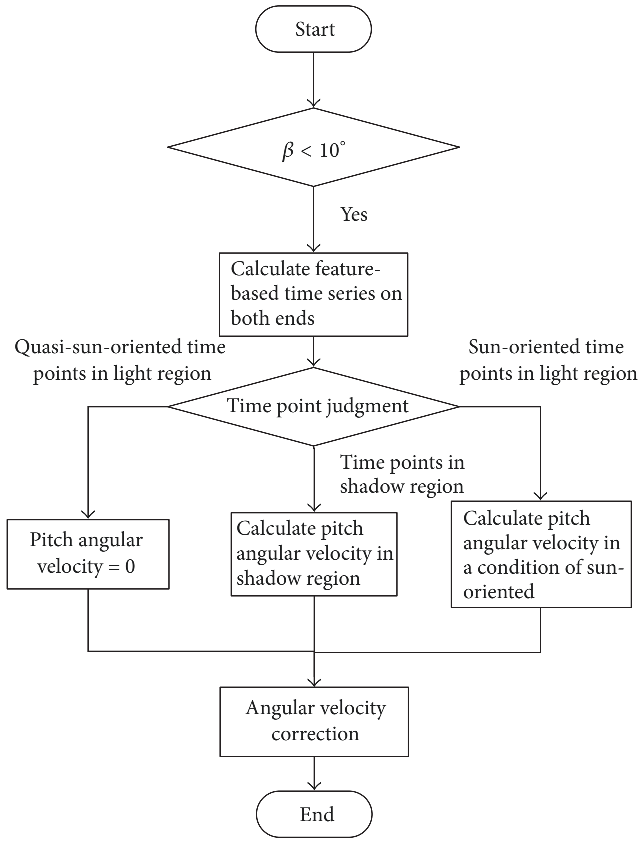

Figure 3: Solar tracking of panels guidance process in a condition of small angle.

In the one-dimensional condition, pitch angle of such a position is the limited angle. For pitch angular velocity of the shadow region, it can be figured out by the following equation.

$$V_2 = \frac{2\alpha_{\mathrm{MAX}}}{T_{\mathrm{shadow}}}, \quad (10)$$

where T_{shadow} is calculated based on the earth shielding angle; that is, $T_{\mathrm{shadow}} = (\pi - \gamma)/\pi \times T$.

4. System Simulation and Analysis

4.1. Sun-Oriented Angle of Limited Angle Constraint Based on a Pattern Partition Strategy. Under constraint described in Section 2, according to guidance strategy design results, simulation analysis was conducted for two modes of large and small β angles under the limited angle constraint. In the case that the two-dimensional turntable rotates along two directions, angles, angular velocities, and angular accelerations were computed. Corresponding simulation results have been shown in Figure 4.

If $\beta = 10^\circ$, the azimuth angular velocity up to 0.32°/s and above is very large. Consequently, it fails to meet low disturbance requirement of microsatellites. The angular velocities should be subjected to smoothing to reduce solar tracking accuracy and further realize the purpose of low disturbance.

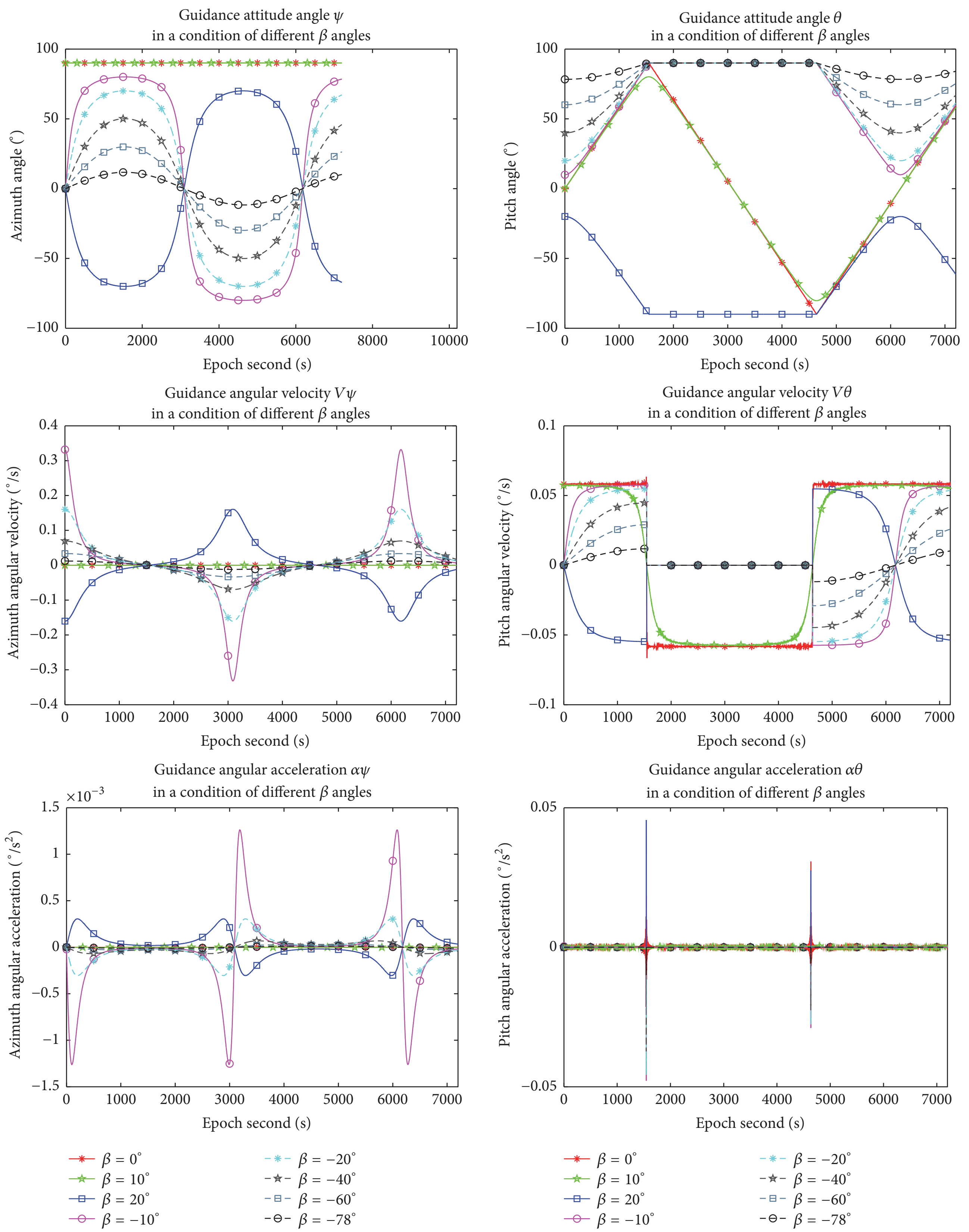

Figure 4: Two-dimensional pointing situations under limited angle constraint based on a pattern partition strategy.

Table 1: Main performance of the turntable.

Item	Value
Range of rotation angle	Azimuth angle: ±90°, pitch angle: ±90°
Range of stationary tracking angular velocity	0.03°/s to 1°/s
Maximum tracking angular acceleration	No less than $1^\circ/s^2$
Minimum tracking angular acceleration	No more than $0.008^\circ/s^2$
Stabilization of dynamic tracking rotation angular velocity	Better than 0.01°/s (velocity: no more than 0.2°/s)

4.2. Tracking Situations Based on Feature-Based Time Series. In terms of the guidance strategy design based on feature-based time series, time of an orbit period was divided into seven segments according to seven characteristic time points under the circumstance that switching point of two modes was $\beta = 10^\circ$. In this manner, large disturbance torque that may be incurred targeted at the satellite platform attitude control could be avoided. Subsequently, two-dimensional solar tracking simulation was conducted and the relevant results have been given in Figure 5.

Figure 5 signifies that the angular deviation between two dimensionalities and sun-oriented direction are both small in consistency with a guidance strategy based on the feature-based time series, guaranteeing the acquisition of satellite energy. Concerning details of the integrated deviation, please refer to Section 4. As for the angular velocity, the azimuth angular velocity that originally fails to meet relevant requirements have been controlled below 0.2°/s and values of angular velocities within the entire orbit are those of several speeds matched with time series. This is beneficial for lowering bearing losses of the turntable. In terms of angular acceleration reflecting disturbance torque, solar tracking curve angular acceleration without optimization changes frequently. Consequently, not only is long-playing disturbance generated, but reciprocating disturbance gives rise to waste of satellite control resources. In comparison, disturbance can be rather concentrated after the optimization of such an acceleration, which makes the disturbance to satellite minimized.

Additionally, matching between angles at both ends of each sequence can ensure that angle errors of the entire orbit cannot accumulate. Meanwhile, error precision of the angle can be improved along with the increase in density of the time series.

4.3. Error Analysis. Based on joint debugging of MATLAB/Simulink and STK, joint simulation was conducted for guidance law design. While a guidance law calculation generation model, a turntable control model, and a turntable output model were all constructed by Simulink, STK played a role in analog input and solar tracking situation visualization when utilized to output real-time orbit and on-board time. Through calculations of real-time data, real-time tracking conditions were observed to obtain angle errors of solar tracking subjected to a guidance strategy, as shown in Figures 6 and 7.

A one-dimensional solar tracking pattern was utilized under the circumstance of small β angle. The solar tracking error of panels at the stable tracking stage is one β angle. In addition, errors still can be found before or after the light region due to constraint of the limited angle. The maximum value of them can be expressed in $\gamma - \alpha_{\mathrm{MAX}}$.

A two-dimensional solar tracking pattern was utilized under the circumstance of large angle. Errors are incurred in the actual velocity and averaged velocity between tracking points of diverse segments. Moreover, such errors arrive at their maximum values as the azimuth angle crosses zero. In the case that β angle is equal to 10°, the corresponding error can be up to 8.66°. Due to constraints of the limited angle, errors still exist before/after the light region. The maximum value of them can be expressed in $\gamma - \alpha_{\mathrm{MAX}}$.

Solar panels fail to reach their target angle physically because of limited angle constraints, which produces the maximum value of angle error denoted as $\gamma - \alpha_{\mathrm{MAX}}$. Besides, the composition error subjected to a pattern based guidance strategy should be controlled below 10°.

5. Physical System Verification

In order to verify the validity of the proposed method, physical system verification was carried on, which was composed of the on-board computer, power supply, and two-dimensional turntable. The sun vector was taken by recursive calculation, and the guidance data was calculated by the on-board computer according to former method. The rotation of the turntable was controlled to achieve the sun-oriented mode. The turntable was designed for a certain type of microsatellite, and its physical picture has been shown in Figure 8.

The main performance of the turntable has been shown in Table 1.

Based on the microsatellite orbital characteristics, two modes of large and small β angles were selected to verify the guidance method, respectively, in one-year period, the large β angle was $\beta = -23.6^\circ$, and the small β angle was $\beta = 3.6^\circ$. Through the simulation analysis of the two angles, the results have been shown in Figure 9.

Under the circumstance of large and small β angles, there was a small difference between the turntable output attitude and the guidance attitude shown in Figure 4. It meets the requirements of ensuring the low disturbance to the platform, and the maximum angular velocity and the maximum angular acceleration of the turntable should be no more than 0.2°/s and $0.01^\circ/s^2$, respectively. To verify the sun-oriented deviation, the comparison of the turntable output attitude and the sun-oriented attitude has been shown in Figure 10.

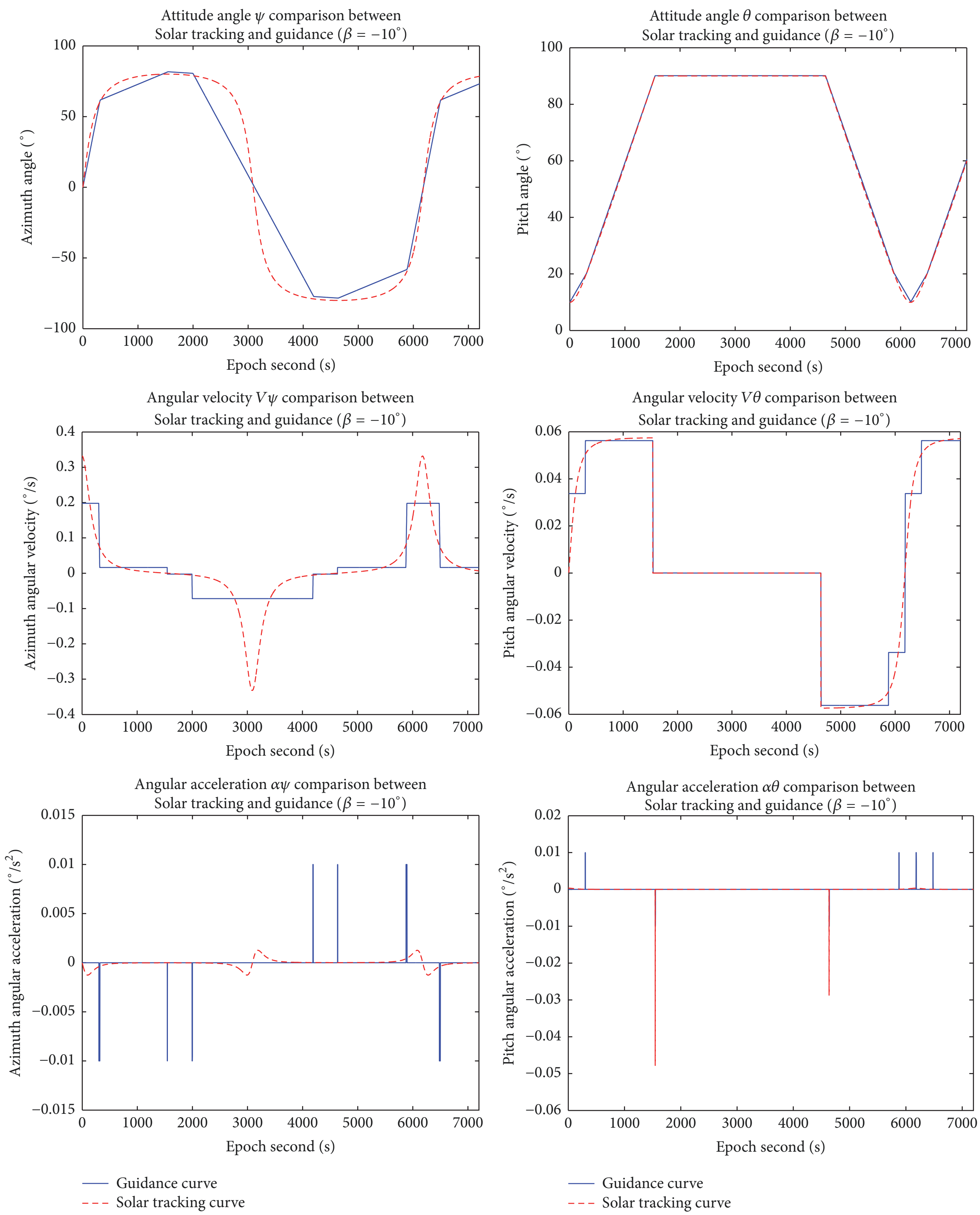

FIGURE 5: Comparison between guidance based on feature-based time series and sun-oriented guidance.

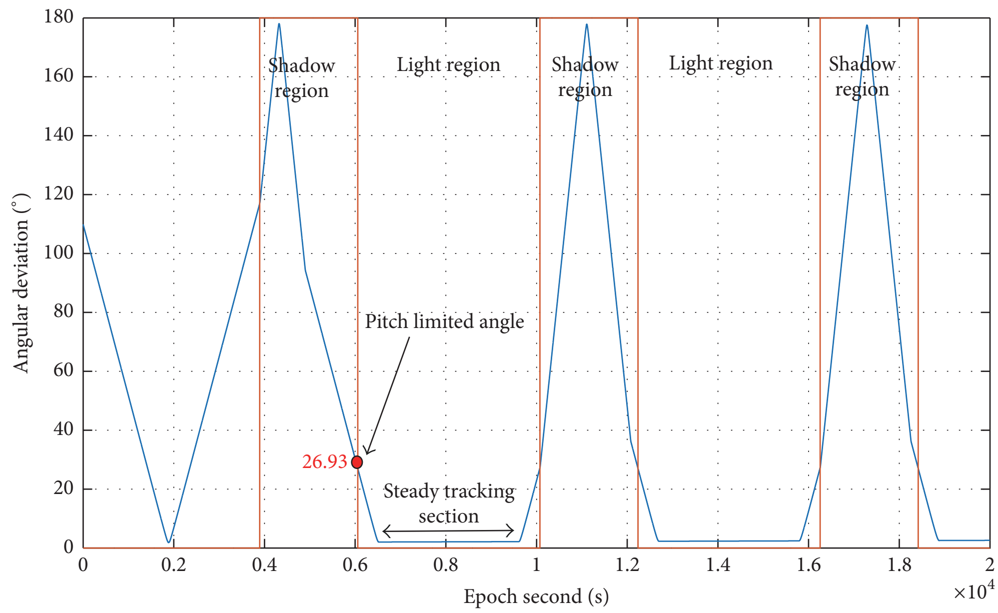

FIGURE 6: Guidance error in a condition of small β angle.

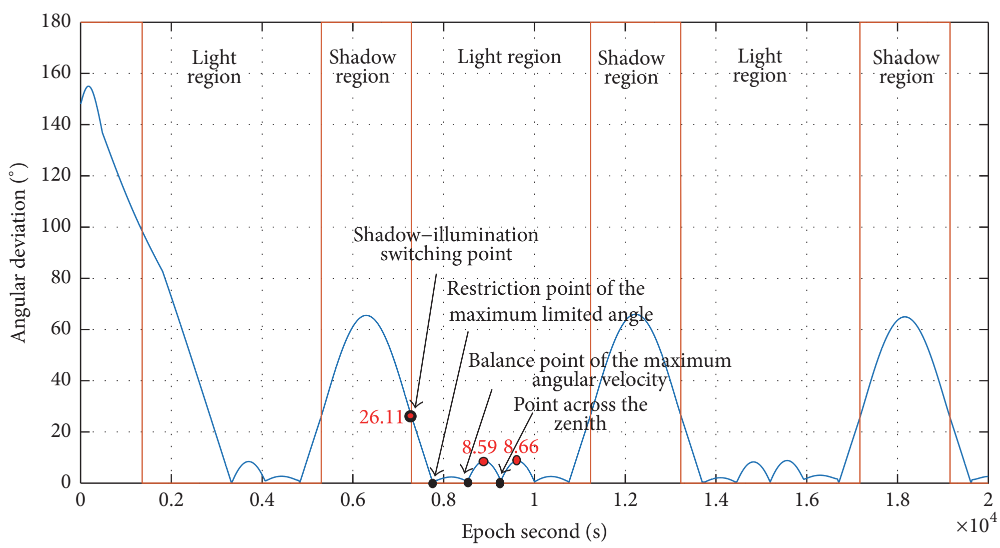

FIGURE 7: Guidance error in a condition of large β angle.

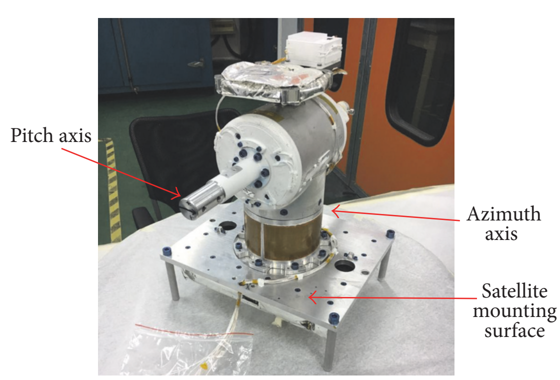

FIGURE 8: Two-dimensional turntable physical picture.

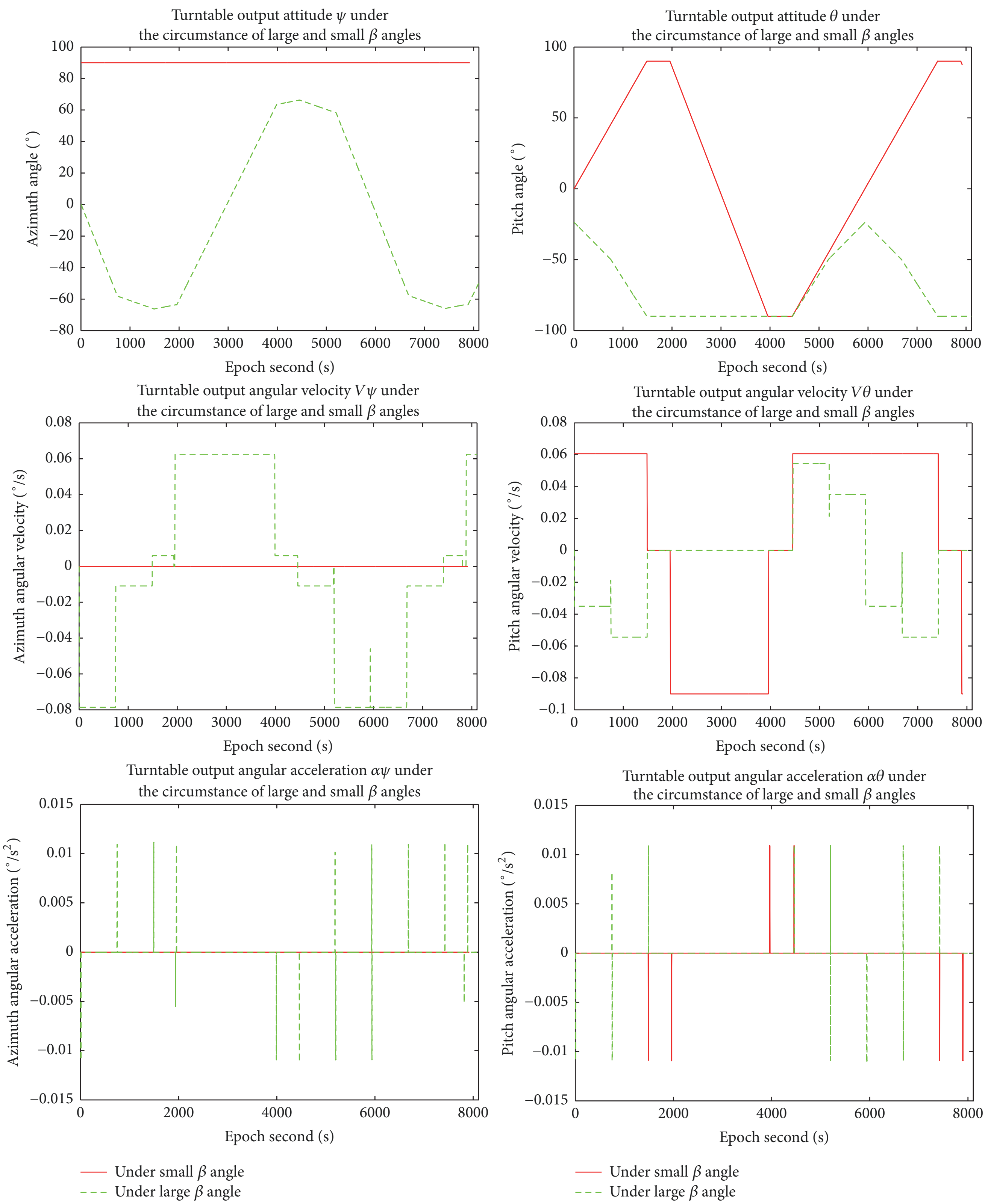

Figure 9: Comparison between turntable output attitude and solar tracking attitude under the circumstance of large β angles.

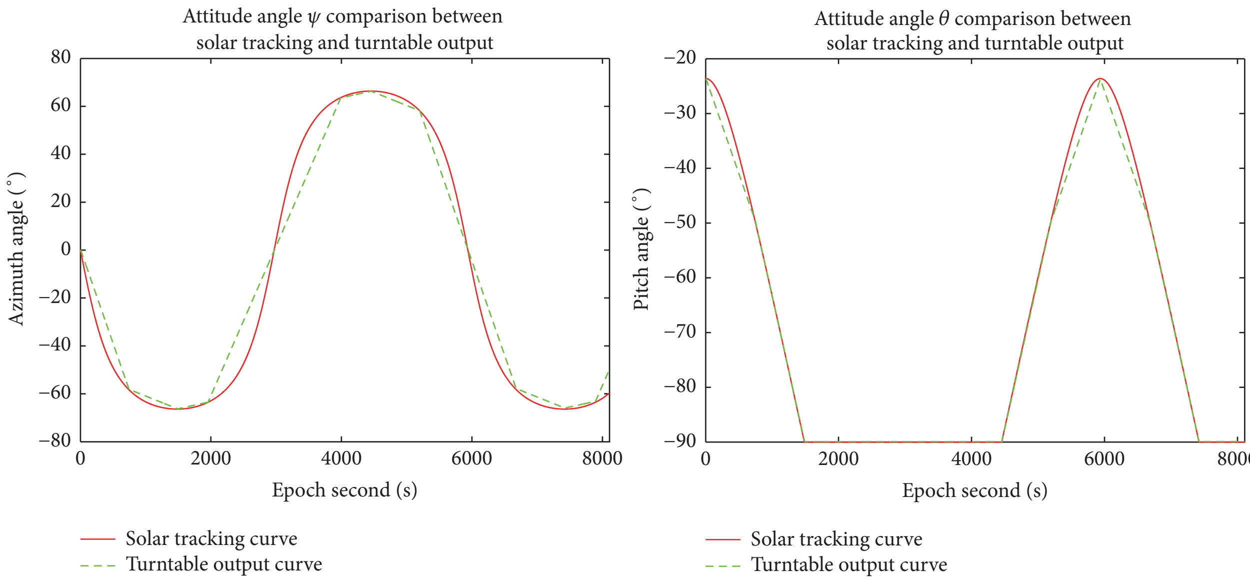

FIGURE 10: Comparison between turntable output attitude and solar tracking attitude under the circumstance of large β angles.

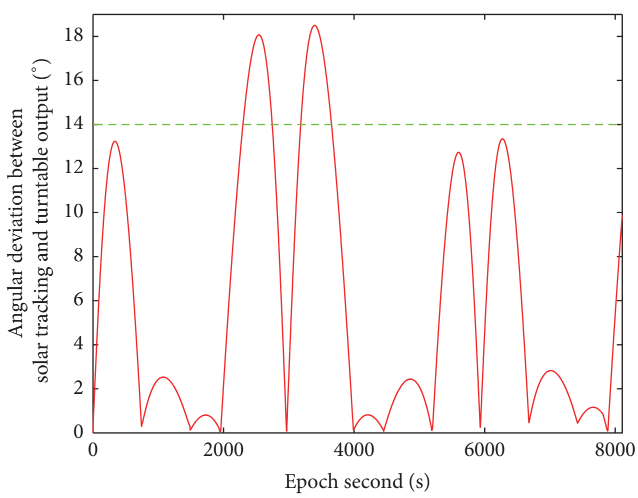

FIGURE 11: Angular deviation between turntable output attitude and the solar tracking attitude under the circumstance of large β angles.

There was a small deviation between the turntable two-dimensional angle and sun-oriented direction during execution of guidance strategy, which could guarantee the acquisition of satellite energy. The composition angular deviation of sun-oriented direction has been shown in Figure 11.

The temporal interval between 2000 s and 4000 s in Figure 11 was in a shadow region. Besides, the composition angular deviation of sun-oriented direction in a sunshiny region should be controlled below 14°, which meets the requirement.

6. Conclusion

A stationary low disturbance solar tracking guidance method applicable to two-dimensional solar panels was proposed to realize enough energy acquisition based on the microsatellite platform. Moreover, it supports payload power consumption demands required by multitype tasks performed by the microsatellite, such as space-based space surveillance, earth observation, navigation enhancement, and low-orbit communication, which fills in the gap of solutions to engineering applications of the microsatellite in two-dimensional solar panels and provides new ideas for replacement of the traditional SADA with two-dimensional turntable. Simulation results demonstrate that such a method has the potential to effectively improve guidance stability of the turntable. Therefore, it is a valid solution to solar tracking stationary guidance problems of microsatellite panels.

(1) Segmental and autonomous switching modes were utilized to extract time series within the satellite orbit period according to feature points for the purpose of guidance planning. Moreover, patterns and time series lengths can be autonomously switched in line with the current positional relations with the sun so as to form two-dimensional solar tracking guidance laws in the period.

(2) The guidance method proposed is not only applicable to diverse near-earth orbits of different orbital inclination, but able to guarantee the solar tracking accuracy of the panels to be below 14° and ensure maximization of energy acquired.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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