Design of Multifunctional Solar Power Generation Control System Based on Active Tracking Algorithm

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Abstract

In order to solve the problem of the world energy crisis and build a conservation oriented society, the solar power generation is widely used all over the world. Solar energy is a kind of clean and renewable energy, so it has become an important research topic to improve the utilization of solar energy. The traditional passive solar panel does not make the utilization of solar energy to reach the highest, in this context, paper puts forward a kind of multifunctional solar power generation control system based on the active tracking algorithm, can realize the active real-time tracking of mobile in the sun, the sun light is always perpendicular to the incident to ensure panels, improve the utilization efficiency of solar energy maximum limit. This topic is fundamentally different from the traditional solar tracking device such as clock and the maximum power solar tracking device, such as passive solar tracking device. Combined with photoelectric solar tracking device, an active solar tracking algorithm is proposed. The algorithm is based on the installation site of solar collectors and specific working time, calculates the solar altitude angle and azimuth angle, automatic correction of the solar collector's point of view, ensure that it always follows the orientation, maximize the use of solar energy. During the actual test, the parameters such as longitude and latitude, time and so on are set for the system by terminal input module. Among them, latitude and longitude can be obtained by means of GPS and other devices, and the time parameters can be referenced to local standards.

Keywords

Active tracking algorithm, Solar power generation, Data fusion algorithm, Solar altitude angle and azimuth, GPS positioning.

1. Introduction

Solar power is recognized as a sustainable way to acquire energy, with the increasing population of the world, the global resources facing a shortage dilemma, the contradiction between energy demand and energy supply capacity have become increasingly prominent, in this context, solar power is getting more and more attention, it is not difficult to see that the near future will be solar one of the world's main source of energy, but also the original issue all the energy of the earth. Solar energy has the advantages of clean, large amount of resources, wide distribution, relatively balanced and mature technology, and solar energy is easily converted to other forms of energy. Therefore, solar energy has a wide range of applications[1]. At present, the solar power industry in our country is still in the lower level of the stage, the main research areas of photovoltaic power generation, after decades of development, China has formed a mature industrial system in some local area, however, through the actual investigation shows that the vast majority of China's solar power generation device has the phenomenon of energy waste the actual solar energy utilization rate is low, the main reason is that the solar power generation equipment is in a fixed position, can not follow the changes of the solar altitude angle and azimuth angle and adjusted to the best position[2]. As a result, these solar power plants work only for a certain period of the day and remain ineffective for the rest of the day.

At present, with the development of science and technology, there are some solar tracking device at home and abroad is summarized, mainly divided into fixed clock type solar tracking device and the

maximum power type solar tracking device, the principle is through several discrete time point to adjust the solar position, so as to improve the efficiency of solar power generation, the device is essentially a passive solar tracking device; the latter is the principle of setting a moment of power type super capacitor, as the position of the solar panel, this device can greatly improve the efficiency of solar power, but in principle, still belongs to the passive solar tracking device[3].

2. System Scheme Design

This chapter of the system each function module design, mainly from the solar automatic tracking scheme design, design, light collection scheme of multi sensor data transmission and automatic identification of priority scheme, cloudy and sunny identification scheme design, data communication scheme design on the five aspects of system design.

2.1 Solar Automatic Tracking Scheme Design

The system can automatically calculate the solar altitude angle and the azimuth according to the geographical location of the angle of the device parameters, combined with the detection results of the weather system, drive motor, complete. Get with the help of GPS terminal equipment through the input module for the system set in the current area of longitude and latitude, time and other parameters of solar collecting location and working time of installation device, which is the basis for real-time calculation of solar altitude angle and the azimuth angle of the system, if the location changes, you will need to enter the geographical coordinates and current time. Calculate the solar altitude angle and azimuth angle according to the solar energy collection device installation location and working time calculation of solar altitude angle and the azimuth angle is one of the emphases and difficulties of the design, to the further study of the algorithm, which is the key to achieve accurate tracking[4]. The stepping motor of the solar collecting device is driven by the angle of STM32 MCU real-time calculation to produce the corresponding pulse to drive the stepper motor, the transmission mechanism of angle of solar energy collection device is driven by the completion of the swing, so as to realize the real-time rotation of solar collectors with the sun position change. Detection of weather condition if the rainy weather, stop on solar tracker angle correction. The practical test shows that the active tracking of solar energy is stable, the precision is high and the reaction speed is fast.

2.2 Design of Light Energy Collection Scheme

Project using solar panels to receive sunlight, according to different light intensity, the photovoltaic effect will be different, the induced current of the solar cell resistance will change the current signal into voltage signal, and then use the microcontroller sampling analysis. Through the process of judgment, and then control the rotating platform, so that the device received the maximum current. The scheme has high efficiency, practicability and sensitive response[5].

2.3 Design of Multi Sensor Data Transmission and Priority Automatic Identification Scheme

Using computer technology, the process of information processing is carried out automatically and synthetically under certain criteria to complete the required decision and estimation task. From a plurality of sensors through a comprehensive treatment algorithm for measuring information, generate more reliable, more accurate and more complete information, and make judgments, estimates and decisions based on this information, the key technology is of the original measured data preprocessing, data association, data and data fusion. Using software programming to solve multi-sensor data fusion and automatic priority recognition, it is real-time, accurate and automatic.

2.4 Design of Recognition Scheme for Cloudy Days and Sunny Days

Through the literature review and consult teachers that can be measured by the pressure sensor principle of clear and cloudy, sunny and cloudy when the air pressure is atmospheric pressure has obvious differences, specifically the sunny days are higher than when it is cloudy. Weather pressure this parameter is little affected by environment, day and night are effective, obtained by programming the value of the pressure sensor, thus distinguishing Yin fine, has the advantages of higher precision, strong continuity[6].

2.5 Design of Data Communication Scheme.

The GSM module is the GSM RF chip, the baseband processing chip, memory, power amplifier devices integrated on a circuit board, independent of the operating system, GSM, baseband processing and RF processing function module provides a standard interface. GSM has many advantages, such as long transmission distance and little environmental impact.

3. System Principle Analysis and Hardware Circuit Design

3.1 System Principle Analysis

The sun tracker adopts the horizon coordinate system, which is intuitive, convenient and operational. However, there are also problems in the calculation of trajectory coordinates which have no specific formula. The specific value of declination angle and angle in relative motion on the ground at any moment in the equatorial coordinate system is strictly known, at the same time, the equatorial coordinate system and coordinate system are closely related, and the motion of the earth so that through the relationship between the astronomical triangle can be obtained by measuring the sun and view of the relationship between the position[7]. Comprehensive analysis, in the sun tracking observation, mathematical model of two dimensional programmable solar tracker using horizontal coordinate system as the reference coordinate system, and with the equatorial coordinates of space coordinate transformation to obtain real-time elevation and azimuth of the sun. This topic through the terminal input module, for the system to set the current area of latitude and longitude, time and other parameters. Among them, latitude and longitude can be obtained by means of GPS and other devices, and the time parameters can be referenced to local standards.

3.2 Circuit Design of System Master Control Module

Through the comparative analysis, mainly consider the power performance, the number of the peripheral control circuit, this paper uses STM32F103RBT6 chip STMicroelectronics, the chip power consumption from the performance and operation speed, memory capacity and stability have met the requirements of the project. The specific circuit diagram is shown in figure 1.

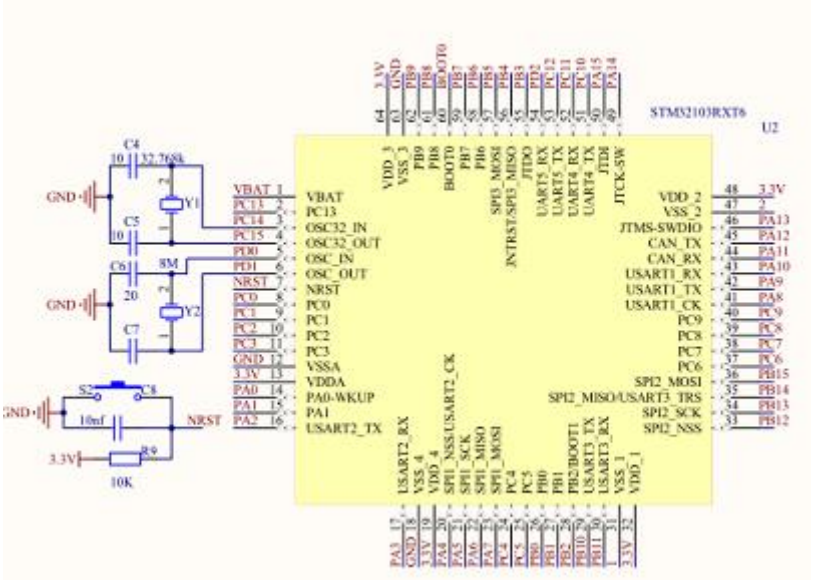

Fig. 1 Schematic diagram of the main control module circuit

3.3 Circuit Design of GPS Positioning Module

GPS positioning module circuit for the latitude and longitude information collection of solar panel, the design of the active tracking algorithm to use the latitude and longitude information of solar panel, in order to prevent the error location information, subject set up pre filtering circuit in GPS positioning module front-end circuit, filter circuit principle diagram as shown in figure 2, through

comparative analysis and the actual verification, the project finally adopted GPS positioning module module, which can minimize human error. The system GPS positioning module circuit adopts the UBLOX-6M GPS module, and the schematic diagram is shown in figure 3.

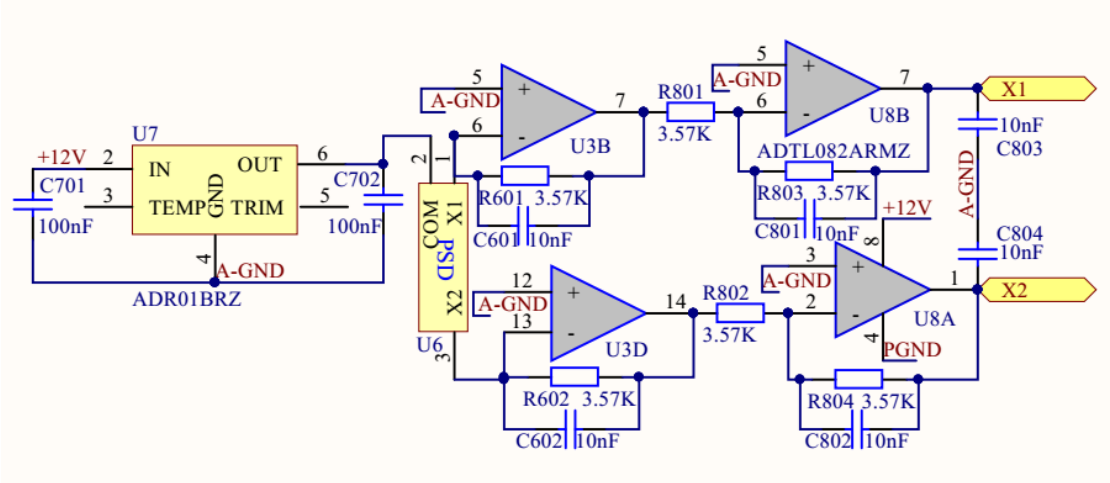

Fig. 2 Schematic diagram of the pre filtering circuit

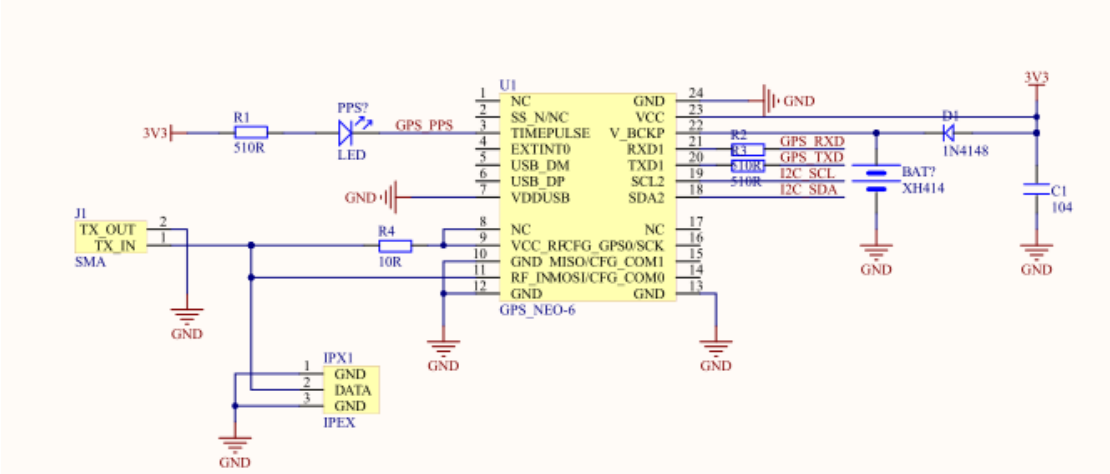

Fig. 3 Schematic diagram of GPS positioning module circuit

3.4 Circuit Design of Air Pressure Sensor Module

As pointed out earlier, in order to accurately identify the cloudy and sunny, the air pressure sensor, the pressure sensor in order to facilitate, this system uses the BMP180 module integration, is a high precision, small volume, low energy consumption of the pressure sensor can be used in mobile equipment, the circuit diagram is shown in figure 4.

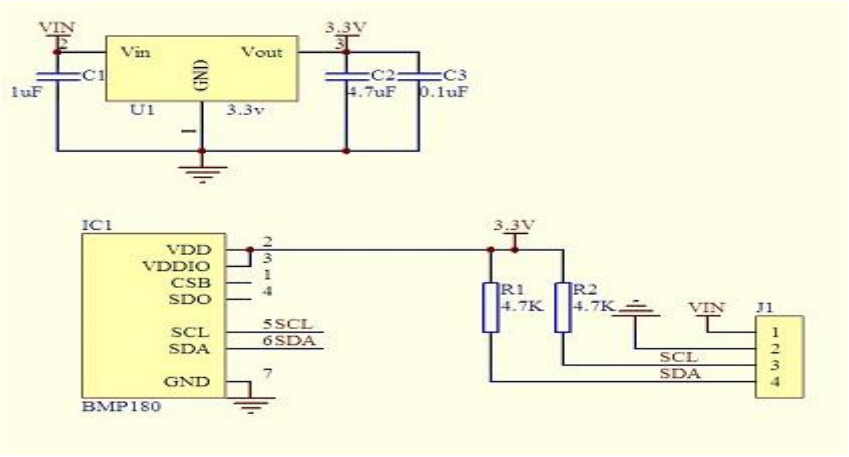

Fig. 4 Schematic diagram of pressure sensor module circuit

3.5 Circuit Design of Temperature and Humidity Sensor Module

The system uses DHT11 temperature and humidity sensors as a system to obtain the source of temperature and humidity parameters. DHT11 is a temperature and humidity sensor with calibrated digital signal output[8]. Accuracy humidity +-5%RH, temperature +-2 centigrade, range humidity 20-90%RH, temperature 0~50 DEG C. The specific circuit is shown in figure 5.

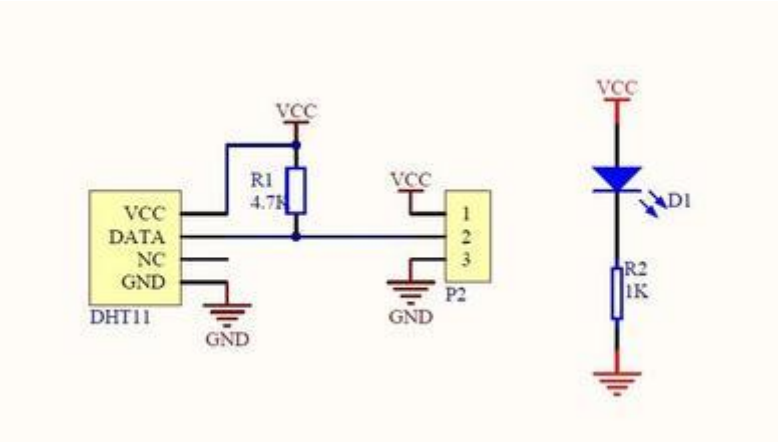

Fig. 5 Schematic diagram of temperature and humidity sensor module

3.6 Circuit Design of Other Circuit Modules

In addition to the 4 main modules and other modules of the system, such as dust sensor circuit, power management module, servo control module, DCDC module, high current power conversion module, light intensity detection module, charging module etc. due to the reasons of space, do not introduce. The intent of the overall circuit diagram is shown in figure 6.

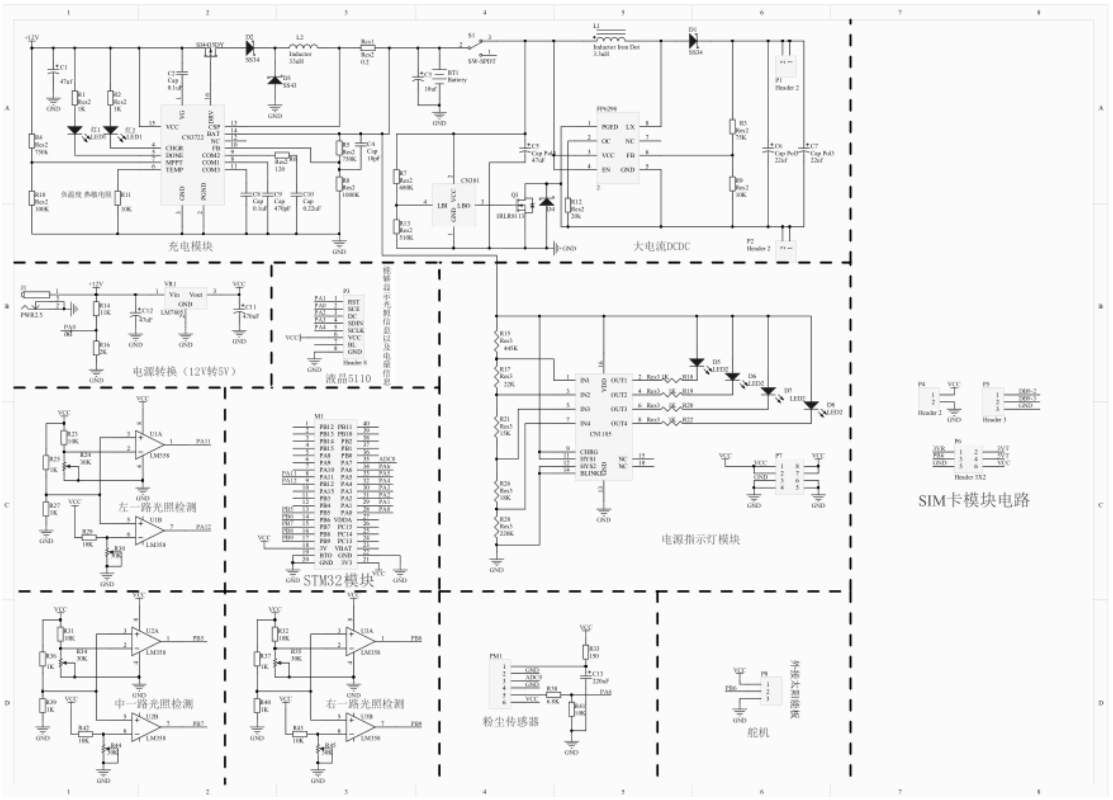

Fig. 6 Schematic diagram of system integrated circuit

4 System Software Design

The design in this chapter of the system software, the software design is a key step in the realization of the system, not only to achieve the function, but also pay attention to optimization, in order to more clearly, the system software flow chart is given and a simple description[9]. The system uses KEIL4 as the software compiling environment and ST-LINK as the system debugging simulator. It mainly includes the system flow chart design, the solar automatic tracking subroutine flow chart design, the data acquisition flow chart design, the solar movement track monitoring flow chart design and so on.

4.1 System Overall Flow Chart Design

The system is energized, self-test failed, system restart, self-test after identify whether it is sunny, if is to start the automatic tracing subroutine, or start photoelectric mode, then the final data acquisition, data transmission, and enter the next cycle. The overall flow chart is designed as shown in figure 7.

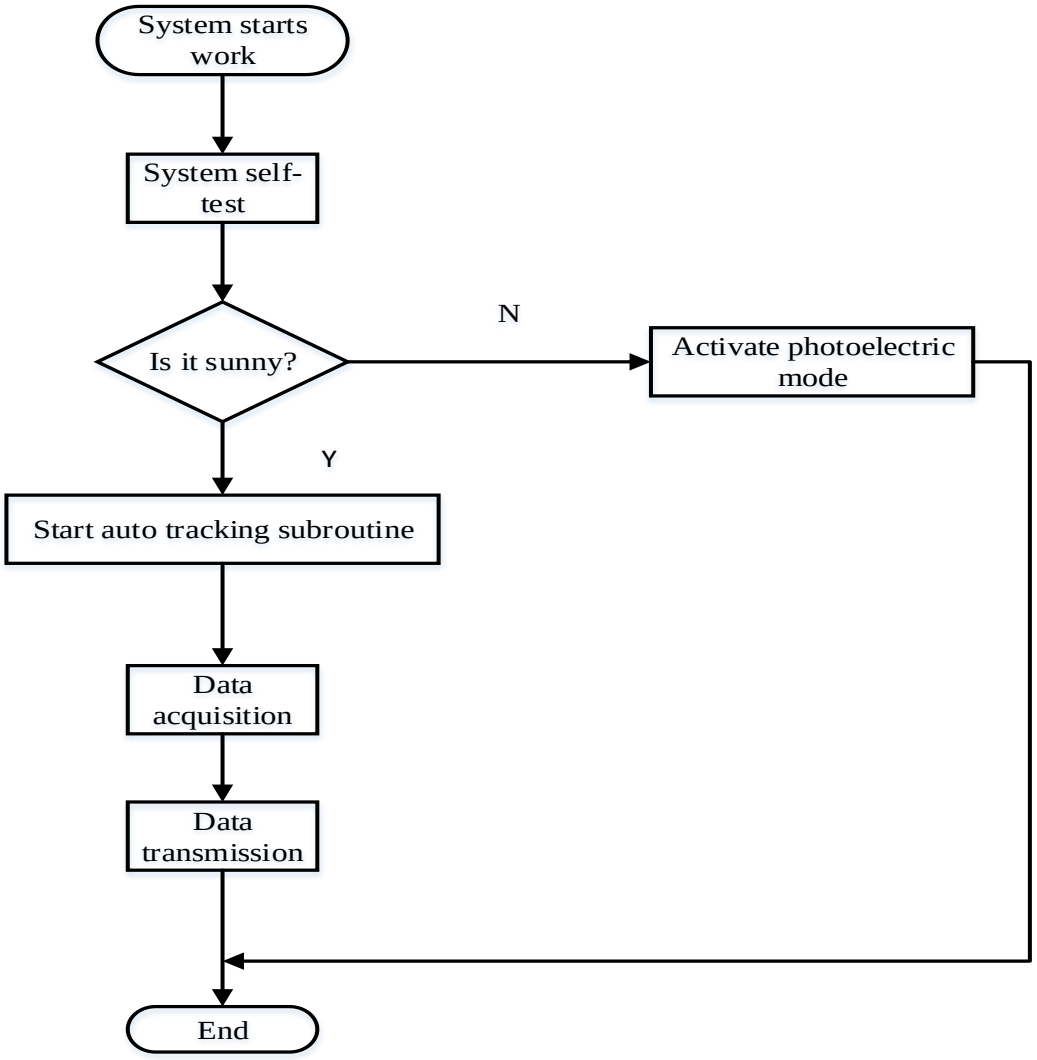

Fig. 7 Schematic diagram of system overall flow chart design

4.2 Flow Chart Design of Solar Automatic Tracking Subroutine

Automatic solar tracking is the core issue of the subroutine program, the main process as follows: enter the solar automatic tracking subroutine first to determine whether to start the automatic tracking, and then read the clock information, then determine the solar panel reference position and start the data collection procedures[10], the final judgment of intensity information, and then call the different modes of solar tracking subroutine. The flow chart of the solar automatic tracking subroutine is shown in figure 8.

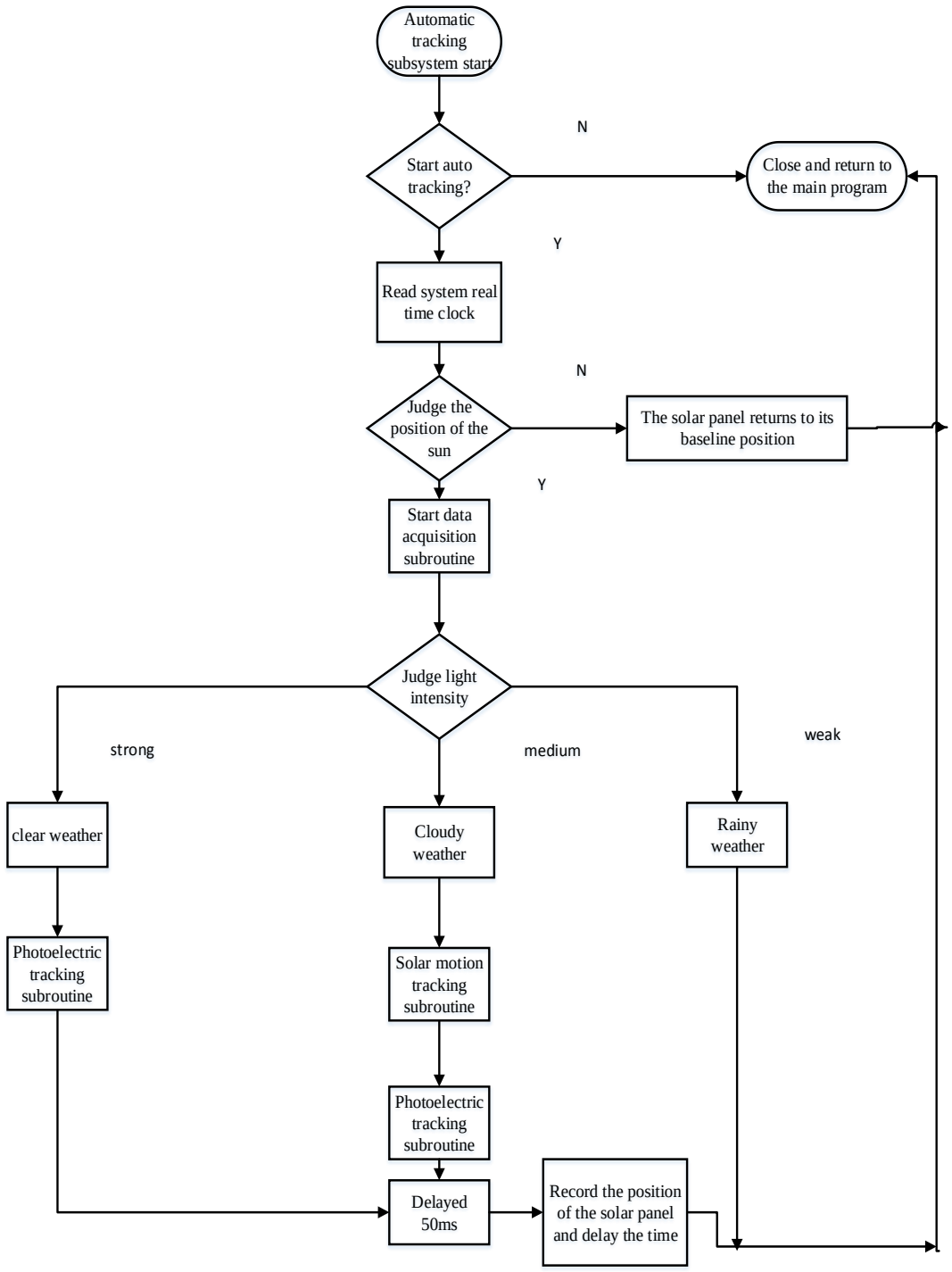

Fig. 8 Schematic diagram of flow chart of solar automatic tracking subroutine

4.3 Data Acquisition Flow Chart Design

The data acquisition system mainly includes the latitude and longitude information and time information to calculate the position of the sun by the user's location, in the data collection, in order to reduce the interference caused by ambient light and weather data inaccuracy, increase the sampling frequency, and the average value is taken as the signal sampling value. The data flow chart of the system is shown in figure 9.

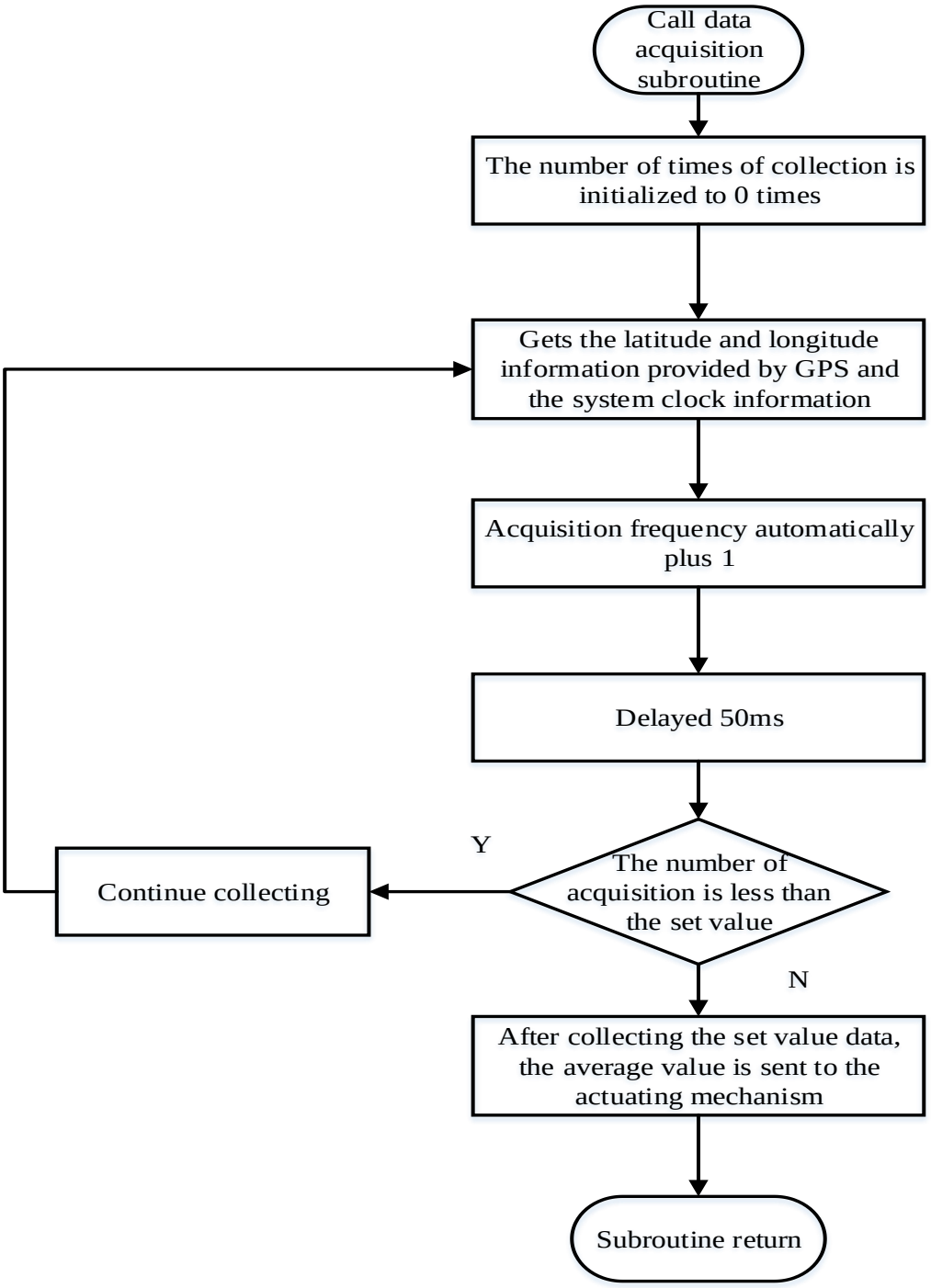

Fig. 9 Schematic diagram of data acquisition flow chart design

4.4 Solar Flow Track Monitoring Flow Chart Design

This section is the basis of precise tracking of the sun. The position information of the sun is acquired in real time based on the longitude and latitude and time information of the user's location[11]. The flow chart of the sun trajectory monitoring is shown in figure 10.

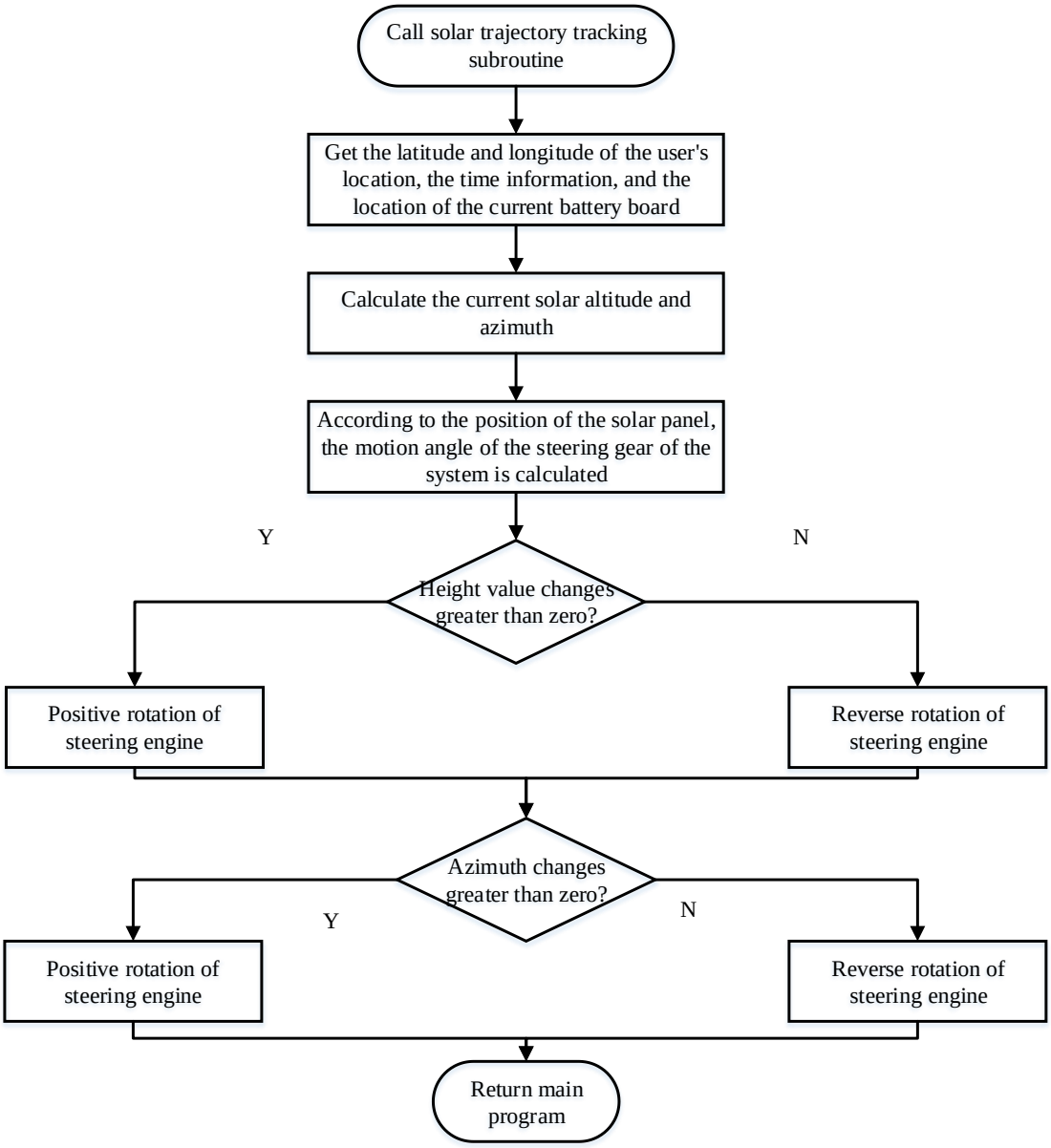

Fig. 10 Schematic diagram of solar motion trajectory monitoring flow chart design

5 Experimental Verification

The core function of this chapter of the test system, the latitude and longitude information, time information and other external users need to use the location of the input information, through the movement of the sun derived astronomical algorithm formula, estimate the sun azimuth and elevation angle, and drive the actuator motion through the MCU, to take the initiative to real-time tracking of the sun[12]. Due to the sun in the day to run slowly, from nine a.m. to four p.m. by this system, divided into eight sampling points, pointing to the solar panels were measured (including azimuth and elevation), in order to show the test results clearly, this paper presented in tabular form, the specific test circuit schematic shown in figure 11, the test results as shown in table 1 and table 2.

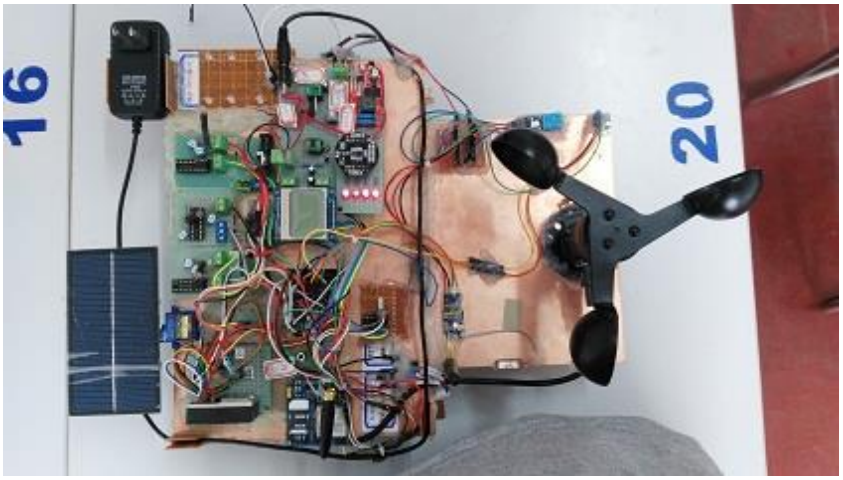

Fig. 11 Schematic diagram of system overall test circuit

Table 1. Active tracking test results for solar panels (from 9 a.m. to 12 a.m.)

Test time	9 a.m.	10 a.m.	11 a.m.	12 a.m.
Latitude and longitude of the test site	EL121.579308 NL38.917841	EL121.579308 NL38.917841	EL121.579308 NL38.917841	EL121.579308 NL38.917841
Test value of solar altitude angle	47.79	58.55	67.01	72.03
Test value of solar azimuth	79.01	65.53	42.12	-0.16
Standard solar altitude angle	48.85	60.07	69.73	74.25
Standard solar azimuth	81.06	67.11	43.39	0.00
Height angle error	2.1699%	2.5303%	2.4666%	2.9898%
Azimuth error	2.5289%	2.3543%	2.9269%	Meaningless
Remarks	Tested at an altitude of 45 meters			

Table 2. Test results of active tracking of solar panel (from 13 p.m. to 16 p.m.)

Test time	13 p.m.	14 p.m.	15 p.m.	16 p.m.
Latitude and longitude of the test site	EL121.579308 NL38.917841	EL121.579308 NL38.917841	EL121.579308 NL38.917841	EL121.579308 NL38.917841
Test value of solar altitude angle	67.75	58.55	47.63	38.15
Test value of solar azimuth	-44.51	-65.23	-79.01	-87.91
Standard solar altitude angle	69.74	60.07	48.85	37.22
Standard solar azimuth	-43.40	-67.13	-81.07	-89.94
Height angle error	2.8535%	2.5304%	2.4974%	2.4987%
Azimuth error	2.5576%	2.8303%	2.5410%	2.2571%
Remarks	Tested at an altitude of 45 meters			

By table 1 and table 2, it can be concluded that the overall error of the system is between 2%~3%, and within a certain range of error, the system accuracy is up to the predetermined requirement.

6 Conclusion

Passive solar project broke through the traditional tracking system, presents a practical and feasible, and deduces the formula with the solar astronomical algorithm trajectory, with latitude and time parameters of user location, high precision, active solar tracking device. In view of the photosensitive sensor to measure the sunny days, affected by the weather, the measurement accuracy is not high, the system adopts high precision pressure sensor, the sunny days than in cloudy air pressure have obvious difference, so fast and accurate and clear and cloudy, cloudy in the solar energy does not work, enable the standby power supply in a timely manner, to ensure the normal operation of the system. The system adopts dual mode control strategy, which greatly improves the adaptability of the system, and lays a good foundation for the practical use of the system. In conclusion, this system by tracking control of solar panels can improve the utilization rate of solar energy; reduce the cost of photovoltaic power generation, the further development of solar energy utilization, conducive to escape from economic constraints.

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