Ultra-light linear sun sensor

Abstract:

This instruction describes the appearance features, technical specifications, interface definitions and communication protocols of Ultra-light linear sun sensor .

Key Words: Satellite, Digital Sun Sensor, Specification, Protocol

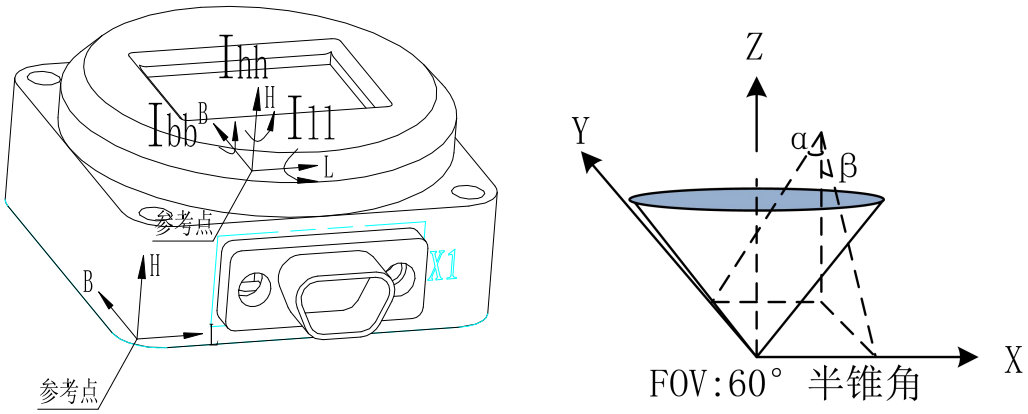
1. Sun sensor overview

1.1 Appearance

Fig1. Sun sensor

1.2 The definition of coordinate

- the origin of measurement coordinate system is at the center of image sensor;
- Z-axis is perpendicular to image sensor direction along the optical axis, piointing to the external of sensor;
- Y-axis is parallel with mounting plane and opposes to connector;
- X-axis, Y-axis , and Z-axis composes a coordinate system in right-hand.



Notice: $\alpha = a\tan(X/F), \beta = a\tan(Y/F)$ sun vector=$[\tan(\alpha), \tan(\beta), 1.0]$

Fig.2 the outline and coordinate system schematic of sun sensor

1.2 Interface

J30J-9ZKP external connector is used on sun sensor, and its pin definitions are shown in Table 1.

Table 1 definition of sun sensor pins

Pin No.	Signal type	signal characteristics
1.	+5V Power voltage	Sun sensor +5V power supply
2.	GND	Ground
3.	C2CK	Program download line
4.	C2D	Program download line
5.	RX+	sun sensor receiving +
6.	RX-	sun sensor receiving-
7.	TX+	sun sensor sending +
8.	TX-	sun sensor sending-
9.	None	None

1.3 power supply source

Power supply source :DC ＋5V±0.4V

2． Operating instructions

a、 First, mounts the sun sensor on a certain fixed component, making its detecting side towards the optical source.

b、 Connects sun sensor with on-board electronic system via J30J－9ZKP.

c、 Turn on DC 5V power.

d、Read the related attitude information via the serial port. Thus, sun sensor begins to work in normal.

e、After work, turn off 5V power.

3． RS422 serial communication protocol

Asynchronous serial 422 electrical interface standard is adopted by sun sensor.

3.1 transmission rate

Serial communication adopts standard full-duplex 422 interface, the baud rate is 11520bps, sun sensor replies with data no more than 300bytes one time.

3.2 transmission format

A byte transmits ten bits of every sequence, the order is:

a. one start bit

b. eight data bits(low bit first, then high bit)

c. one stop bit

d. no parity check bit

Multi-bytes transmit high byte first, then low byte.

SUM: Cumulative sum, that is low eight bits of effective data field cumulative sum.

SUM＝（Data1＋Data2＋…+DataN）%256;

3.3 interface circuit

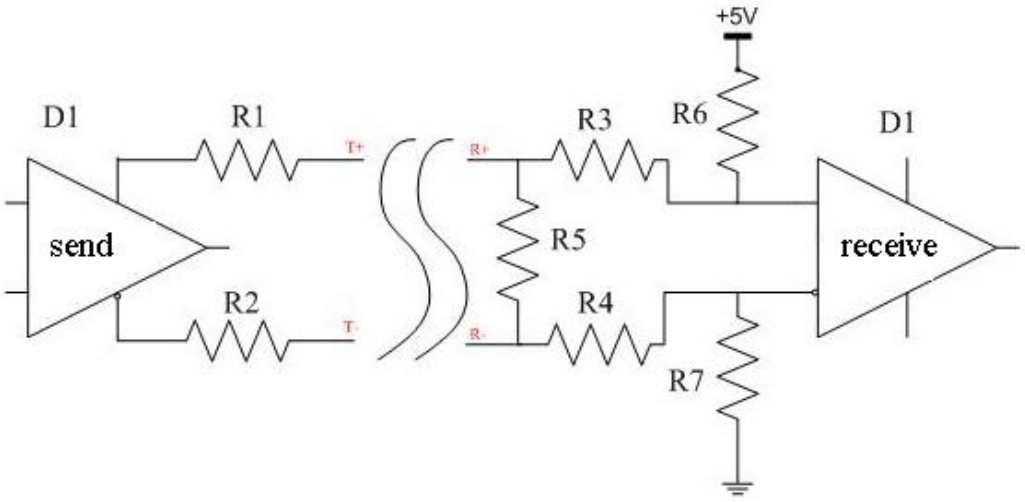


Fig. 3 interface circuit

Transceiver chip is MAX13433E(D1， 5V); R1, R2 is 100Ω; R3-R5 is 1kΩ; R6, R7 is 10kΩ.

3.4 communication format protocol

Housekeeping communicates with sun sensor in two formats: command format and data format.

Table 2 command format from housekeeping to sun sensor setting parameter

number of bytes	Purpose	data	remark
1	unit address	addr	For example: E4H:represents the address of sun sensor A.
2	Send command identifier	8BH	
3	command code	Command1_High	Command code 1* high byte
		Command1_Low	Command code 1* low byte
4		Command2	2 command code 2

5	command code checksum	SUM	low eight bits of command code cumulative sum

* The detailed definitions of command code are as follows.

Command1_High（command type）

5H adjust the maximum exposure time

AH adjust low-level threshold

CH adjust high-level threshold

Command1_Low|Command2（command specific value）

maximum exposure time range: 01EH to 064H（30 to 100ms）

Low-level threshold range: 005H to 030H(5 to 48 normalized threshold) value range of low level threshold

high-level threshold range: 031H to 0C0H（49 to 192 normalized threshold）value range of high level threshold

Table 3 command format of sun sensor reply setting parameter

number of bytes	Purpose	data	remark
1	unit address	addr	For example: E4H:represents sun sensor A address
2	Reply command identifier	8BH	

Table 4 Command format of obtaining sun sensor data by housekeeping system

number of bytes	Purpose	data	remark
1	unit address	addr	For example: E4H:represents sun sensor A address
2	Request data identifier	90H	
3	command code		00H: requires attitude result 11H: requires image data

Table 5 data format replying from sun sensor to satellite

number of bytes	Purpose	data	remark
1	Reply data identifier	addr	For example: E4H:represents sun sensor A address
2		90H	
3	valid data field	WorkState	work state of sun sensor
4		DelayTime	attitude delay
5		Threshold	normalized threshold
6		ExposedTime	exposure time
7,8		tanα_DataH	α angle high 16 bits
9,10		tanα_DataL	α angle low 16 bits
11,12		tanβ_DataH	β angle high 16 bits
13,14		tanβ_DataL	β angle low 16 bits
15	cumulative sum	SUM	low 8 bits of valid data field cumulative sum

Table 6 data format replying from sun sensor to satellite (image)

number of bytes	Purpose	data	remark
1	Reply data identifier	addr	For example: E4H:represents sun sensor A address
2		90H	
3	Valid data field	Threshold	normalized threshold
4		ExposedTime	exposure time
5		imagestart	pixel start point greater than threshold
6		spotnum	**Number of spots**
7、8		Pixel-0	Image data
9、10		Pixel-1	
…			
…			

271、272		Pixel-133	

3.5 definitions of sun sensor data

The followings provide reply data definitions: each separator corresponds to one byte.

Parameter adjustment command: Addr|8B: Represents successful receiving of the parameter adjustment command sent from on-board computer.

Table 7 parameter adjustment command example

command name	Command content	Host computer send	Sun sensor reply
Adjust maximum exposure time	Adjust maximum exposure time to 100ms.	E4 8B 50 64 B4	E4 8B
Adjust low-level threshold	Adjust low-level threshold to 20	E4 8B A0 14 B4	E4 8B
Adjust high-level threshold	Adjust high level threshold to 66.	E4 8B C0 42 02	E4 8B

（1） **Send image data:**Addr|90|Pixel0|…..|Pixel255:Pixeln represents pixel gray，the value is 0 to 65535。

command name	Command content	Host computer send	Sun sensor reply
Send image	Require image data	E4 90 11	E4 90 1b 14 32 03 pixel-0…pixel-133

（2） **send working state and attitude angle**

command name	Command content	Host computer send	Sun sensor reply
send work state and attitude angle	Requires attitude result	E4 90 00	15 byte result data

The definition of 15 bytes of result data is as follows:

Addr |90 |Workstate |DelayTime |tan α _DataH1 |tan α _DataH2 |tan α _DataL1 tanα_DataL2 | tanβ_DataH1| tanβ_DataH2 | tanβ_DataL1| tanβ_DataL2 | SUM|

Workstate(working state of sun sensor)

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Work state 0: valid 1: failure	**Gain mark 0:low gain 1:high gain**	**change mark of parameter 0: parameter is not changed 1: parameter is changed.**	**Number of spots**				

DelayTime（attitude delay information，unit:ms）。

Attitude delay time is the time from sun sensor obtaining N image data to the sending of corresponding attitude computing result. The time sequence is shown in figure 4.

DelayTime = 1.5*exposure time+attitude computing time+(current exposure time+current attitude computing time)

Where, exposure time is about 10ms, the time for computing attitude is about 30ms. Attitude time delay is about 75ms to 115ms.

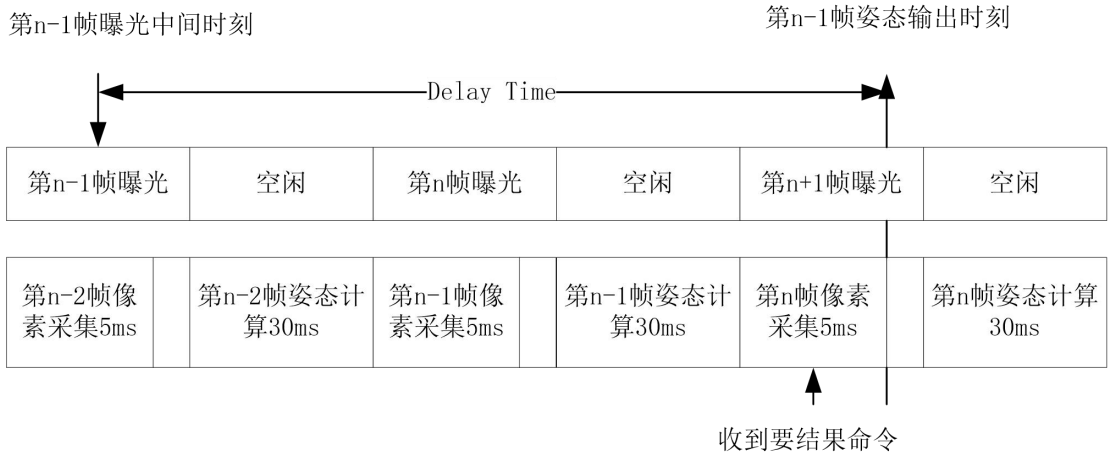


Fig. 4　Processing sequence

The time delay from sun sensor receiving host computer request to sending attitude data is less than 10ms.

[tanα_DataH|tanα_DataL](Float output of tangent for α attitude angle, sixteen high bits, sixteen low bits.)

[tanβ_DataH|tanβ_DataL](Float output of tangent for β attitude angle, sixteen

high bits, sixteen low bits.)

SUM: low 8 bits of effective data field cumulative sum

For example: command: e4,90,00，

Return value:e4,90,43,0a, 1b,14,3f,56,cf,3c, 3f,13,cd,3a, 75。

43H represents: work state is normal, high gain, parameter is not changed, the number of spots is three.

0aH represents: state delay time is 10ms.

1bH represents: the threshold is 27.

14H represents: exposure time is 20ms.

3fH,56H,cfH,3cH represents decimal 0.839100d(tan40°);

3fH,13H,cdH,3aH represents decimal 0.577350d(tan30°);

Then, the sunlight vector is: (0.839100,0.577350,1);

75H are the low 8 bits of

(43H+0aH+1bH+14H+3fH+56H+cfH+3cH+3fH+13H+cdH+3aH=0375H).

5. Notices

(1) Please cover the optics top and mirror cube lid when they are not used, to protect from contamination.

(2) Anti-static measurement should be taken when handling the connector of sun sensor.

(3) Sun sensor should be stored in the conditions of dry and normal temperature (10°C to 30°C) when it is not used for long time.