Array digital sun sensor

Abstract:

This instruction describes the appearance features, technical specifications, interface definitions and communication protocols of Array digital sun sensor .

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

1. Sun sensor overview

1.1 Appearance

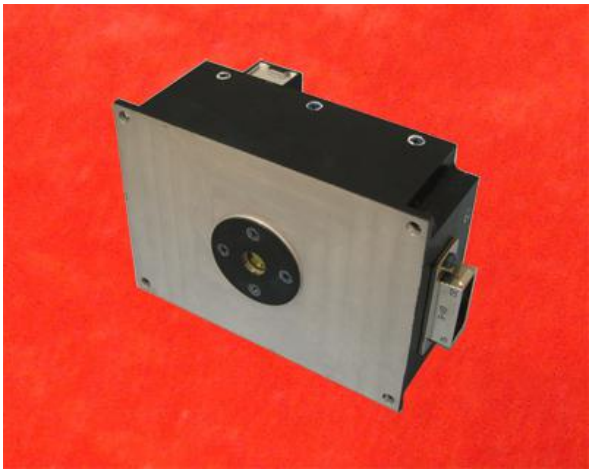

Fig.1 Sun sensor

1.2 interfaces

The product's power supply and data communication with onboard electronics are implemented via J14A—20ZJ connector. Its pin definition is shown in the following table.

Pin No.	Signal (functional)description	voltage V	Current A	Polarity	Remark
1,2	RX+				
3,4	RX-				
5,6	TX+				
7,8	TX-				
9	none				
10,11	ground				
12	none				
13,14	+5V				
15	3.3V				Used for FPGA program downloading
16	TDO				
17	TCK				
18	TMS				
19	TDI				
20	shell				

1.3 power supply source

Power supply source:DC＋5V±0.5V, ripple is less than 100mV.

2. Operating instructions

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

b、 Connect sun sensor with on-board electronic system via J14A－20ZJ.

c、 Turn on DC 5V power.

d、 Read the related attitude information via the serial port after 10-30 seconds (wait for program configuration complete). 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 38.4Kbps.

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

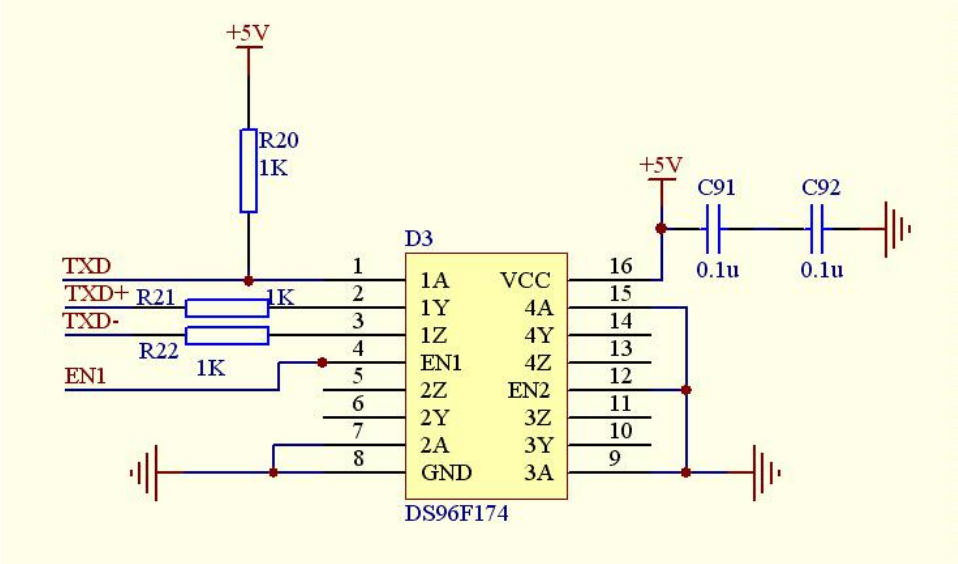

Fig. 2.signal send circuit

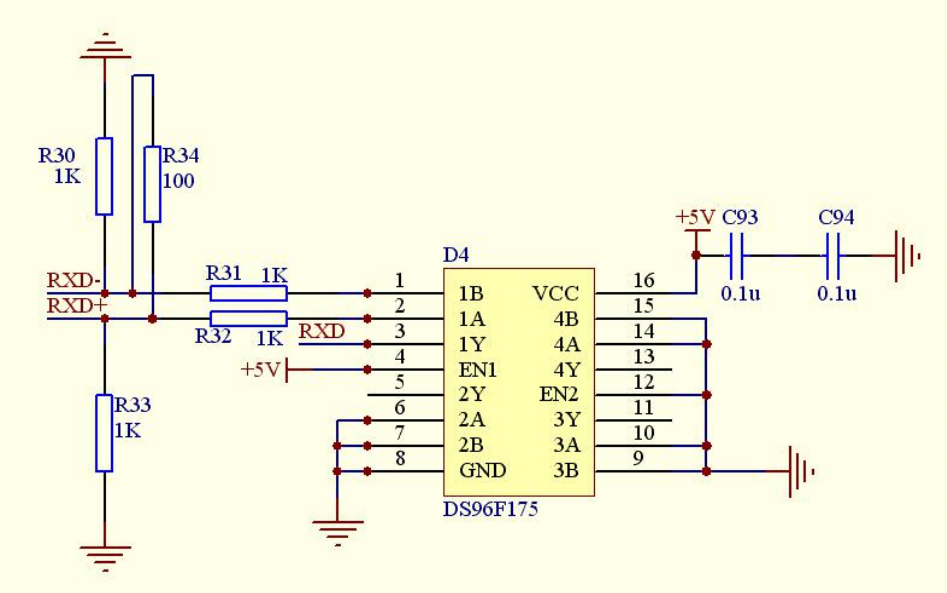

Fig. 3.signal receive circuit

3.4 communication format protocol

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

Table 1. Format of command from housekeeping to sun sensor

number of byte	purpose	data	remark
1	unit address	addr	for example: E4H:represents the address of sun sensor A.
2	Send command identifier	8BH	
3		FFH	
4	Number of command code bytes	02H	2 bytes
5	command code （Command）	Command_High	command code high-byte
6		Command_Low	command code low-byte
7	Command code checksum	SUM	low eight bits of command code cumulative sum

Command code (command)purpose	CXXXH: reconfigure sun sensor 31YYH: set up exposure low-level, YY represents the value of exposure parameter 32YYH: set up exposure high-level. YY represents the value of exposure parameter

Table 2. Return format of command received by sun sensor

number of bytes	purpose	data	remark
1	unit address	addr	For example: E4H:represents sun sensor A address
2	Reply command identifier	8BH	
3		FFH	
4		00H	

Data format sent by housekeeping to sun sensor

number of bytes	purpose	data	remark
1	unit address	addr	E4H:represents sun sensor A address
2	Request data identifier	90H	
3		FFH	
4		00H	

Table 4 data format of sun sensor replying housekeeping

number of bytes	purpose	data	remark
1	Reply data identifier	addr	E4H:represents sun sensor A address
2		90H	
3		FFH	
4	Number of Reply data bytes	05H	Reply data bytes:5 bytes
5	valid data field	WorkState	work parameter of sun sensor
6		α_DataH	α angle high byte
7		α_DataL	α angle low byte
8		β_DataH	β angle high byte
9		β_DataL	β angle low byte

10	cumulative sum	SUM	low 8 bits of valid data field cumulative sum

Table 5 data format of sun sensor reply housekeeping

byte	Bit	purpose	parameter	remark
WorkState	Bit7	Work state flag bit		0: normal 1: failure
	Bit6	current exposure level		0:low level；1: high level；
	Bit5	Number of spots flag		11: Represents the number of spots is more than 2.
	Bit4			
	Bit3	(bit7-bit4) of current threshold		
	Bit2			
	Bit1			
	Bit0			
α_DataH	Bit7	α angle sign bit	α_sign	0(+)；1(-)；
	Bit6	α angle integer component (rad)	α_integer	Value is : $Bit6*2^{1}+Bit5*2^{0}$
	Bit5			
	Bit4	α angle decimal fraction component(rad)	α_fraction	Value is: $Bit4*2^{-1}+Bit3*2^{-2}+\cdots$ + $Bit0*2^{-5}+Bit7*2^{-6}+\cdots$ + $Bit0*2^{-13}$
	Bit3			
	Bit2			
	Bit1			
	Bit0			
α_DataL	Bit7			
	Bit6			
	Bit5			
	Bit4			
	Bit3			
	Bit2			
	Bit1			
	Bit0			
β_DataH	Bit7	β angle sign bit	β_sign	0(+)；1(-)；
	Bit6	β angle integer component (rad)	β_integer	Value is: $Bit6*2^{1}+Bit5*2^{0}$
	Bit5			
	Bit4	β angle decimal fraction component(rad)	β_fraction	Value is: $Bit4*2^{-1}+Bit3*2^{-2}+\cdots$ + $Bit0*2^{-5}+Bit7*2^{-6}+\cdots$ + $Bit0*2^{-13}$
	Bit3			
	Bit2			
	Bit1			
	Bit0			
β_DataL	Bit7			
	Bit6			

	Bit5			
	Bit4			
	Bit3			
	Bit2			
	Bit1			
	Bit0			

Figure 4 shows the attitude angle definition in the coordinate system of mirror cube and sun sensor, where, $\alpha = \arctan(X/F)$； $\beta = \arctan(Y/F)$。

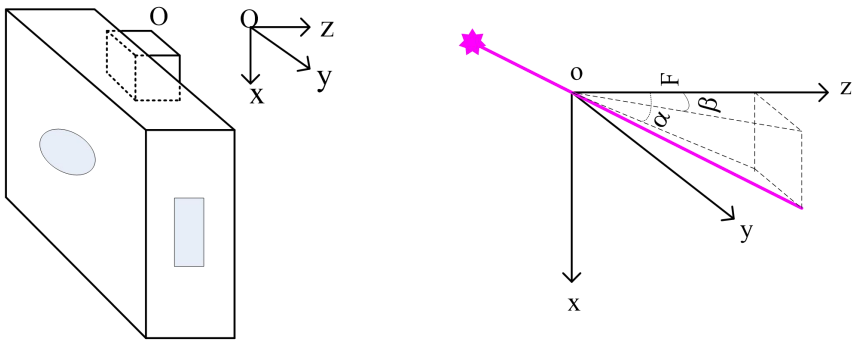

Fig .4. Coordinate systems and attitude angle definitions

3.5 Attitude conversions in the mirror cube coordinate system

A、Solar light direction vector A in the sun sensor coordinate system is determined by attitude α, β output from sun sensor:

$$A = \begin{bmatrix} F\tan\alpha \\ F\tan\beta \\ F \end{bmatrix} = \begin{bmatrix} e1 \\ e2 \\ e3 \end{bmatrix}$$

B、Vector A' converted to mirror cube coordinate system:

$$A' = \begin{bmatrix} f1 \\ f2 \\ f3 \end{bmatrix} = \begin{bmatrix} a_1(e1+dx)+a_2(e2+dy)+a_3e3 \\ b_1(e1+dx)+b_2(e2+dy)+b_3e3 \\ c_1(e1+dx)+c_2(e2+dy)+c_3e3 \end{bmatrix}$$

$$dx = e1[q_1r^2+q_2r^4+q_3r^6]+[p_1(r^2+2e1^2)+2p_2e1e2][1+p_3r^2]$$

$$dy = e2[q_1r^2+q_2r^4+q_3r^6]+[p_2(r^2+2e2^2)+2p_1e1e2][1+p_3r^2]$$

$$r^2 = e1^2+e2^2$$

Table 6 shows specific parameter values, and the involved calculation

will be performed by housekeeping system.

Table 6.conversion parameter of sun sensor

q_1	q_2	q_3	p_1	P_2	P_3
-6.0904e-7	2.313e-12	-4.513e-18	9.9383e-8	3.7891e-7	3.05e-6
a_1	a_2	a_3	b_1	b_2	b_3
0.9999	0.0134	-0.0004	-0.0134	0.9999	-0.0033
c_1	c_2	c_3	F		
0.0003	0.0033	1.0000	269.5530		

4. Commands and data format examples

(1) High-level exposure time is set to 0x15(decimal 21) line:E48BFF0232*1547*;

(2) Lower-level exposure time is set to 0x15(decimal 21) line:

:E48BFF0231*1546*;

(3) Control sun sensor to reconfigure logically: E48BFF02C*000C0*;

(4) Housekeeping system requests result data from sun sensor

: E490FF00;

(5) If the result data is: E4 90 FF 05 68 4A E0 BA E0 2C

it means:68[0 1 10 1000] represents work state, indicates work in normal, exposure level is high, the number of spots is 2, the threshold of image is 8;

4A E0[0 00 1101011100000] is α attitude angle, value is＋0.83984375 rad;

BA E0[1 01 1101011100000]is β attitude angle, value is－1.83984375 rad;

2C is the low 8 bits of [68＋4A＋E0＋BA＋E0];

5. Software default parameters

exposure low-level:55 line（0x0e）;

exposure high-level:70 line（0x12）;

threshold median:40;

upper limit of the threshold:100;

lower limit of the threshold:24;

6. 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.