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WIDE-FIELD SUN SENSOR

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Wide-field sun sensors (WSS) are used on various Russian artificial satellites of the Earth and on the interplanetary stations. The distinctive feature of such the WSS is possibility to obtain the whole spherical field of view, which is realised by only two optical heads with high angular resolution. It is impossible to realise it using other, more narrow-field, devices including ones of static type.

The WSS is an electro-optical scanning device, whose principle of operation consists in generation of the output signals, which contain information about the Sun angular position in the device frame, by means of scanning the field of view with two V-shape slits. Based on the information, which contains in the WSS output signals, the angular displacement of the SV axes from the direction towards the Sun can be determined in the device frame and in the SV fixed frame.

The advanced WSS were developed taking into account the design experience for similar devices, researches on possibility to increase accuracy of determination of the Sun centre angular co-ordinates, to increase the device lifetime, to reduce the device power consumption, mass and dimensions.

For the WSS presented in the given paper, the Fig.1 illustrates principle of operation. The main operational assemblies and units of the WSS are shown in this figure. According to its operation two units realise the WSS: scan unit (SU) and electronic unit (EU).

Fig. 1.

The SU performs scanning the field of view by two slit angular fields 1, 2 and generates the following pulses:

- KC1 when sunlight flux S comes to the photodetector 3 through the angular field 1;
- KC2 when sunlight flux S comes to the photodetector 4 through the angular field 2;
- raster pulses, which contain information about the angular fields' rotation angles φ_1 and φ_2 , using the code limb 8 with the raster 11 marked on it;
- HO starting pulse to measure the angle φ_1 and angle φ_2 using the stroke 12 on the code limb.

The EU performs:

- Transformation of the time intervals between the pulses HO, KC1 and KC2 into a binary digital code convenient for further processing in the SV onboard computer;
- Control of the OU operation;
- Generation of the required voltages for power supply of the SU and EU;
- Other auxiliary operations (generation of sign of the Sun presence in the field of view, telemetry information, etc.).

The photodetectors 3 and 4 are two-element silicon photodiodes, whose sensitive elements are connected in opposite to reduce errors of determination of the Sun centre angular co-ordinates. The moment of zero value of difference signal from both sensitive elements is fixed as the time of the pulse KC1 (KC2) registration. Comparing with formerly developed devices, where the moment of KC1 (KC2) registration was fixed by a comparator of the videopulse front edge, the component of error, caused by alteration of the photodetectors' integral sensitivity and alteration of the comparator threshold, is eliminated in the described device. The only error component remains in the given case - due to alteration of the elements' sensitivity relative to each other during the period of exploitation.

As the signal preliminary amplification unit 5 amplifies the video-signals from both photodetectors, so for their identification the pulse from one of the photodetectors is provided with a marker, i.e. an auxiliary pulse preceding the main one.

The pulses received from the scanning unit are normalised in amplitude and width by the unit 13 for further processing in one-chip microprocessor.

The measurement pulses MP of $2\pi 2^9$ spacing, which are used to measure the rotation angles of the angular fields, are formed from the pulses containing information about the angle φ_1 and angle φ_2 , as well as the pulses fmod1 fmod2 are formed. The last mentioned pulses are used to generate three-phase voltage for the motor M to stabilise its rotation rate.

Microprocessors 14 together with the command unit 15 form the averaged values of the rotation angles φ_1 and φ_2 in the form of 18-bits binary numbers $N1_0$ and $N2_0$.

The corresponding constants are stored in the unit 13 to take into account the WSS systematic errors. These constants are used at forming the numbers $N1_0$ and $N2_0$.

The numbers $N1_0$ and $N2_0$ are transferred into the I/O unit (IOU) for further transfer into the SV computer.

The Sun centre angular co-ordinates are calculated in the SV computer according to the expressions:

$$\alpha = N1_0 \delta_0 + N2_0 \delta_0 / 2 + A$$

$$\beta = \arctg \{ [\sin(N2_0 \delta_0 + B) / 2] / \operatorname{tg} g \},$$

where :

- δ_0 is the angular scale of the N1 and the N2 numbers, which is equal to $2\pi 2^{18}$;
- g is the inclination of the angular fields relative to the rotation axis;
- A, B – are the constants depending on choice of the frame for the rotation angles φ_1 and φ_2 pick up.

Microprocessor 14 also forms the three-phase voltage to feed the motor M and stabilise its rotation rate. The unit 16 amplifies the potentials received from the microprocessor 14 to control operation the motor M.

The motor M is the DBM type torquer.

The power supply BP transforms the onboard voltage of 27 V into the voltages of 15 V and 5 V.

The WSS described above (its production index is 331K) is implemented in its structure as a single unit. The device technical characteristics comparing with formerly developed wide-field sun sensors, which are exploiting now, are shown in the Table 1.

Table 1.

WSS TECHNICAL CHARACTERISTICS

Characteristic	WSS production index		
	251K	281K	331K
Field of view, degr.	90 × 180	40 × 180	90 × 180
Limit error, arc.min	3	3	1
Resolution, arc.sec	30	20	5
Noise, arc.sec	60	—	30
SU mass, kg	1.6	2.0	1.5
EU mass, kg	1.4	—*	--
Consumption, W	6	2**	3
Voltage, V	27	12.6	27
Resource, h.	33000	16320	100000

* The device electronic unit is combined with electronic units of the SV other devices.

** Without the electronic unit consumption.

The total sum of the device 331K technical characteristics shown in the Table 1 ensures broad utilisation of the given device for the advanced SV, including communication and navigation satellites.