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PROCESSING OF THE RADIATION MEASUREMENT SIGNALS IN THE SPECTROMETRIC DEVICES OF REMOTE SOUNDING

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Abstract – Undersatellite systems of remote sounding (USRS) of the terrestrial plants are enough effective for the solution of many important problems. Research of the natural resources, monitoring of the environment's state, observation of state of the agriculture and water facilities, also the natural cataclysms development dynamics observation problems, etc. are among them. The remote sounding for the military and prospecting purposes is very important as well.

In turn, USRS, equipped by board special gears and computer facilities, are realized on the basis of aircraft, including the small-sized and cost-effective pilotless aircraft (planes, helicopters). The conditions of measurement, conversion and processing of the signals in USRS demand higher and rigid technical and metrology indexes of the board devices.

Multi-channel spectrometers of the various types are one of the board devices, carried out the measurement in visible range and near infrared range of electromagnetic radiation's spectrum. The output signals of these spectrometric devices are formed after preprocessing the radiation signals, coming from the researched terrestrial plant, the measurement standard and the sky accordingly, on the board. Therefore the measurements with help of the spectrometric devices are fulfilled in the following four different regimes: "terrestrial plant", "sky", "standard" and "darkness current", which are usually installed with help of the special optical-electromechanical blocks (modulators), characterized by lag effect, hardness of construction and setup, high consumption of electric energy and insufficient reliability. All showed above raise mass-size indexes of the spectrometric devices, hardware expenditures, diminish speed and reliability.

Key words: remote sounding, liquid crystallic converter, spectrometer

1. USAGE OF THE LIQUID CRYSTALS

In the various constructions of the multi-channel spectrometers, depending on the demands and functional dependencies, a number of channels are 24-240, sometimes even more.

Availability of N measurement channels and necessity of sequential processing signals of the shown channels are disadvantage of the shown devices.

Exception or significant raise of the disadvantages of the spectrometric devices, shown above, are realized due to the application of the new blocks on the basis of the electro-optical effects of liquid crystals which are widely popular and applied successfully in the different fields of science and engineering.

The liquid crystals (LC) are the special class of materials. Some of the interesting properties of the LC allowed to use them in the different fields of the modern technology. The modern liquid crystallic displays are applied in TV, personal computers, cell telephones, etc. LC differs with the liquid's mobility and rigid body's anisotropy. On external appearance they look like turbid fluid, and in case of location between two electrodes with electric current they transform into transparent crystal. The principles of functioning of the liquid crystallic conductor deflector is based on the effect of violation of full internal reflecting as a result of changing electric field, acted to it. Due to this effect the liquid conductor deflector do possible to act a role of electric-mechanical modulator successfully. As a result, electronic control of the regimes of spectrometric device's operation that is fulfilled with the board microcontroller or computer is carried out.

2. THE SPECTROMETERS BASED ON THE LIQUID CRYSTALS

A block diagram of the multi-channel spectrometer with LC deflectors (modulators) is presented on the fig. 1.

A structure consists of two LC deflectors (LCD1) and (LCD2), block of LCD control (BCF) that consists of two switches (S1), (S2) and supply unit (SU), N-channel block of photo conversion and normalization (BFCN), block of commutation (BC), analog-to-digital converter (ADC), microcontroller (MC) and external storage device (ESD) [1].

Every channel of BFCN has light filter (LF), photoelectric converter (PC) and normalizing device (ND). The deflectors LCD1 and LCD2 are located so that one of them - LCD1 - controls the direction of luminous flux reflected from the researched object (the regime "object") (or from the standard surface - the regime "standard"), and LCD2 controls the direction of luminous flux from the sky ("sky" mode). The program of LCD control is recorded to the ROM of microcontroller in advance. The programs that carry out m-fold (usually m=10) measurement at the channels, computing the average values and calculating the coefficient of spectral luminance (CSL) are saved in the ROM as well.

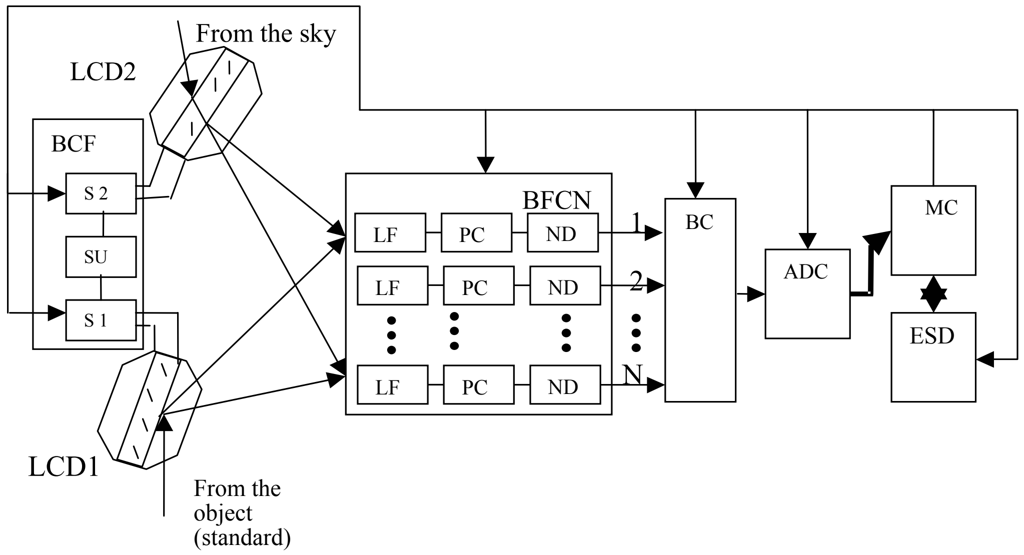

Fig.1. Block- diagram of the multi- channel spectrometer with LC deflectors

According to the command of the MC the switches S1 and S2 of the LCD control block are in the opened state, i.e. voltage is not given to the LCD1 and LCD2 and they work in the reflecting regime. In this case the luminous flux from the LCD1 is directed to the light filters of BFCN where it is divided into N monochromatic components at the visible range of spectrum. The photo converters convert the components to the electric signals, which are normalized by the ND. The signals are passed to the input of ADC with help of BC, converted into the digital form and passed to the resident memory of the MC, where preprocessed and passed to the ESD.

When the MC chooses the regime "sky", the electronic switches S1 and S2 give the voltage to the LCD1 and LCD2. In this case the regime of full internal reflecting is disturbed and both LCD1 and LCD2 cross to the passing regime. Then the LCD1 passes the luminous flux I_{ob} from the object (or I_{st} from the standard), i.e. changes the direction of the shown flux and it does not go to the BFCN. The measurement according to the regime "sky" is fulfilled and then the measurement is converted identically to the regime "object". In the case of giving the voltage to the LCD1 with help of the S1 and switching LCD2 off the SU with help of the S2 both LCD1 and LCD2 direct the luminous fluxes in other direction and they do not go to the BFCN. In this state the regime "darkness current" is fulfilled. The value of the darkness current of the device's measuring tract is measured. The value is equal to some value of luminous flux I_{dc}. According to the value of darkness current the correction of measurement results in other regimes are carried out that lets to increase accuracy of measurement. The values of CSL and spectral reflection (SR) are determined according to the following formulas:

$$CSL_{\lambda} = \frac{I_{ob} - I_{dc}}{I_{st} - I_{dc}}; \quad SR = \frac{I_{ob} - I_{dc}}{I_{sky} - I_{dc}}.$$

The spectrometer operates in the basic regime "object". The values of measurements data in other regimes are periodically innovated depending on the program. In this case the control of modulator that provides this or that regime of measurement is carried out with help of the board microcontroller according to the given algorithm.

One disadvantage of the devices is also the necessity to use the interference light filters in their optical block. The spectral characteristics of these filters, such as visibility, signal/noise ratio are not effective enough. Moreover, for every filtration channel it is necessary to create its own new optical filters that is connected to complexity of their creation and adjusting.

The changing the normal filters with the devices based on the liquid crystals lets to achieve higher visibility in the field of transparency of the filter, larger width of transmission range on the maximum of transmission, creates an opportunity to control the half width of transmission range that improves the technical properties of the spectrometers. In this case the liquid crystallic light filter plays a role of modulator as well and is controlled by the microcontroller. The light filters are fulfilled with an application of the special dyes according to the effect "guest-host". In the case of giving the controlled voltage onto the liquid crystallic light filters with means of control block (BC), the coming luminous flux is filtered at the visible range of spectrum. In the case of stopping the controlled voltage the liquid crystallic light filter does not pass and accordingly does not filter the luminous flux of the object, the sky or the standard. In this case liquid crystal, controlled by the MC with the help of controlling electric signal, fulfils the functions of light filter and modulator. Differing from the interference light filters and its other types until the coming controlling signals the liquid crystallic light filter does not let luminous signal pass. Only after the according controlling signal the liquid crystallic light filter plays a role of light filter fully [2].

A block-diagram of the spectrometer with the liquid crystallic light filters is presented on the fig.2. The device consists of three-channel optic block (OB) including three liquid crystallic light filters (F1), (F2), (F3) which pass three basic components of visible range of spectrum - red (R), green (G) and blue (B). A block of photo conversion and normalization (BFCN) consists of three photoelectric converter (PC) and three normalizing devices (ND). A block of commutation (BC), ADC, a board microcontroller (BM), external storage device (ECD) and block of control filter (BCF), including the controlling key (CK) and supply unit (SU), do not differ from the elements of the circuit on the fig.1 at the purposes and base of elements. At the location of the liquid crystallic light filters F1, F2 and F3 it is necessary to take into account that according to the controlling signal of the MC the controlling key gives voltage onto the electrode of liquid crystallic light filter that originates the regime of passing and accordingly the regime of filtration. The received luminous signals, which accord to the basic colors of visible spectrum R, G, B, come to the BFCN, where they are converted into the electrical signals and normalized under three channels. In turn, the BC sequentially connects the channels to an input of the ADC and after this the digital measuring signals come to an input of the MC and are registered in its resident memory. Then according to the special algorithm the preprocessing (synthesis) of the signals I_R, I_G, I_B and in the case of filling the resident memory of MC the data are passed to the ESD. In the case of stopping the voltage with help of CK the liquid crystallic light filters do not pass the luminous fluxes from the terrestrial object (or standard). At this moment a value of darkness current of the channels is measured and MC carries out the correction of the measuring data in order to increase the measurements accuracy.

The measurements are fulfilled in the visible range of spectrum and the case of three-channel structure is stipulated with three basic colors of visible range of spectrum – R, G and B [3].

Thus, the method minimizes a number of channels of the spectrometer up to three at the simultaneous saving the adequacy to the possibilities of multi-channel spectrometer. As it is known, the colors R, G and B are mutually independent. Fulfilling the measurements in the lengths of waves by the according shown basic colors it is possible to play back every intermediate values of measurement with help of the special formulas.

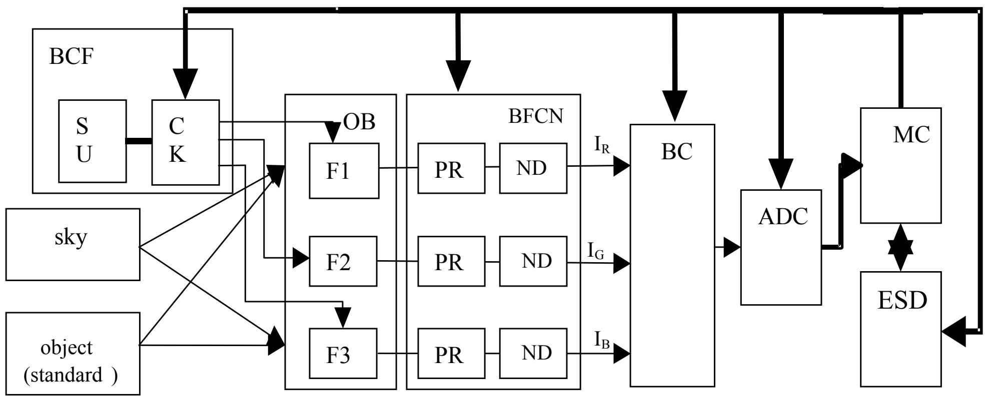

Fig.2. The block diagram of the spectrometer with the liquid crystallic light filters

Thus, usage of the liquid crystallic light filters, controlled by the MC, reduces to absence of mechanical modulator of complicated construction and improvement of the spectral characteristics of the used light filters. It does possible to carry out the measurements on the board of aircraft with the relatively high accuracy and reliability.

If we use the liquid crystallic light filters, controlled by the two-frequency signals, which have an opportunity to pass two basic components of the basic colors of visible range of spectrum, the block-diagram will be presented on the fig.3 [4]. In this case the OB of the device consists of two liquid crystallic light filters F1 and F2. Accordingly, BFCN becomes two-channel device that consists of two PC and ND. The other blocks of spectrum do not change.

Such principle of the spectrometer building is based on that at producing the liquid crystallic light filters according to the method "guest-host" two dyes, colors of which accord to two basic components of visible range of spectrum, are used. In the case of control by other frequency signal the same liquid crystallic light filter will receive the color of other basic component of spectrum and accordingly will pass luminous signals of these colors. Therefore the liquid crystallic light filter can be called as two-frequency light filter. At the producing of second liquid crystallic light filter one dye, according to one of three basic colors, is used. Therefore it is controlled by one frequency signal and accordingly called as one-frequency light filter. Thus, usage of two the liquid crystallic light filters – one- and two-frequency filters – gives an opportunity to carry out measurement at three basic components (R, G, B) of visible range of spectrum.

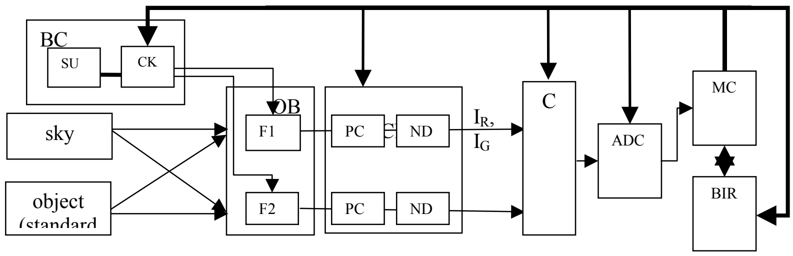

Fig.3. The block-diagram of the spectrometer with two- and one frequency liquid crystallic light filters

3. CONCLUSION

Note that usage of liquid crystallic converters in the spectrometers as liquid crystallic deflector or liquid crystallic light filter improves their quality properties, not requiring an availability of the complicated mechanisms of radiation modulation. At the same time the board spectrometers become more universal, technological and reliable.

As a result of processing the measuring signals, reflected from the terrestrial objects and standard surface, a coefficient of spectral luminance of the objects, that characterizes their state and dynamics of this state change, is determined.

At the given problem, authors have received four patents of Azerbaijan Republic.

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