OPTICO-ELECTRONIC PART OF DIGITAL REGISTRATION EQUIPMENT FOR GEOMAGNETIC FIELD COMPONENTS

Garo Hugassov Mardirossian, Todor Slavkov Djamiykov*, Nikolay Petrov Nenov*

Space Research Institute – Bulgarian Academy of Sciences
Sofia 1000, 6 Moskovska St., P.O.Box 799
e-mail: office@space.bas.bg

***Technical University – Sofia**
Sofia 1000, 8 Kl. Ohridsky blv.
e-mail: tsd@vmei.acad.bg

Keywords: CMOS matrix sensor, optoelectronic device.

One of the essential conditions in updating geophysical equipment is to preserve its technical-operation characteristics. This provides for effective juxtaposition and joint processing of multiannual data obtained by classical data acquisition techniques and instrumentation with data obtained by most modern techniques and instrumentation.

The paper is focused on the transforming part of a unique and copyright-protected equipment complex for on-line digital registration of geomagnetic field components – declination D, horizontal intensity H, vertical intensity Z, and total vector F. The optic-electronic transforming block constitutes the major part of the equipment complex; it determines to a great extent the features and efficiency of the overall complex. The numerous technical and technological problems that emerged during the block's implementation call for special attention and streamlining of its parameters and proper selection of its constituent parts.

The paper suggests a streamlined version of an optic-electronic transforming block with appropriate control unit and data processing software. A concrete computer system including control unit, transformation cycloramas and acquisition algorithms is described which satisfies the requirements for effective juxtaposition and joint processing of multiannual magnetologic data.

1. PROBLEM

In [1] is presented the original and patented method for automatic digital registration of four geomagnetic field components – declination D, horizontal intensity H, vertical intensity Z and total vector F. For composing of a final technical task for the realization of the offered apparatus an optimisation analysis has been done for defining of the main technical and operational characteristics of the separate blocks and of the whole apparatus, as well as cycloramas for measuring and registration [2]. It is suggested a special photodiode line with a compromise between the amplitude resolution and dynamic range of the whole optic-electronic transformer be produced.

2. SUGGESTED SOLUTION

Now it is suggested a different solution for the transforming of the location of the light beam into digital values.

The general block-scheme is shown of Fig. 1.

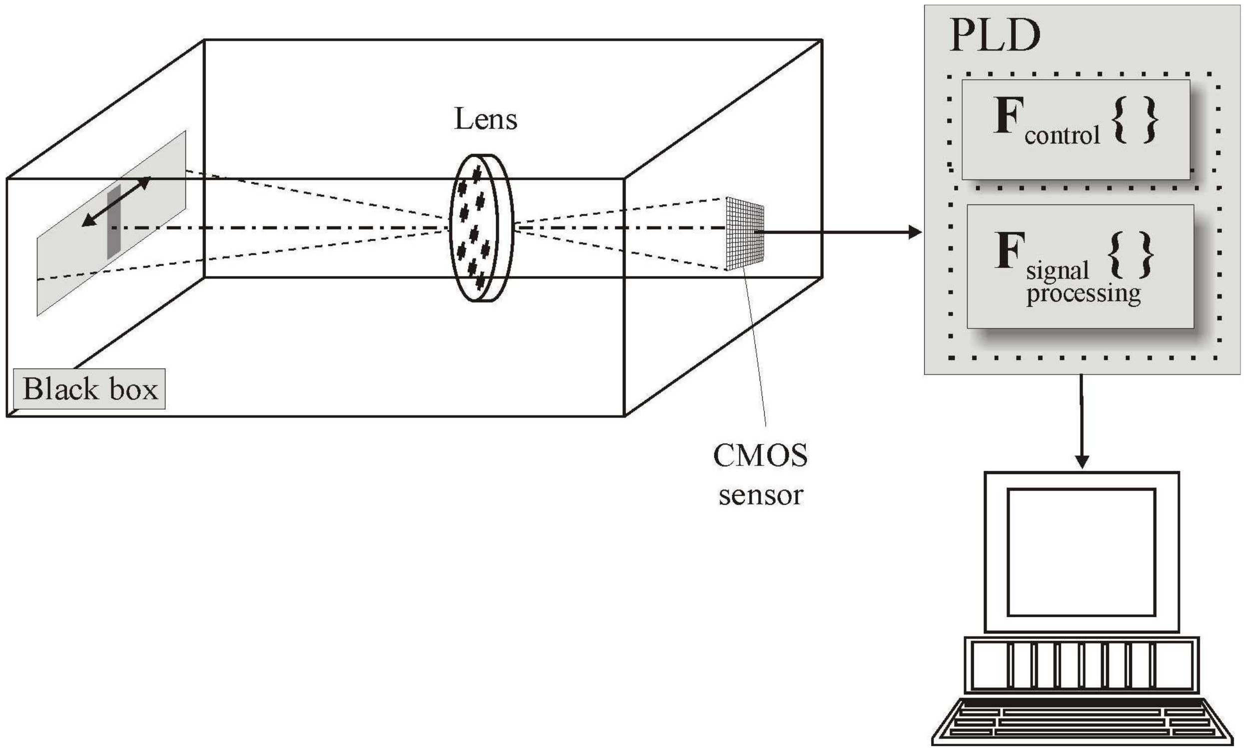

Fig. 1. Block scheme of the optic-electronic device

The photoreceiver (matrix CMOS sensor) has 640 x 480 photosensitive elements where the photosensitive area can be chosen through the appropriate software. In the photosensitive element one control and operating electronic part is integrated. On its output, depending on the programmed operation, digital signals are generated. At first, in 8-bit parallel code an information signal is received from the passing illumination of the separate sensitive elements. Synchronizing signals are generated for the beginning and the end of the row and the sequence (flash). The selection of a suitable factor of amplification for the separate sensitive element and the time of integration is automatically set by the analogue processor built in the sensor.

The digital signals, received from the matrix sensor 4, are sent to a block for digital processing 5. It has been built constructed on the basis of programmable logic crystal from SPARTAN II [3] family of Xilinx company. The full digital processing of the incoming signal is performed in it, namely transforming-coding of the result for indication from seven segment photodiode indication – 6 and forming of sequence code word for transmitting through RS canal to the personal computer. The result of the algorithm work which is indicated by the indication – 6 represents horizontal co-ordinate of the light beam on the screen.

In the personal computer, through RS canal, data about light beam location on the screen are constantly received. In the program media transforming of the data from relative units (number of the element in the row) into absolute units of the geomagnetic field is done. At the same time on given time interval the data back-up is also performed.

For the normal function of the whole device low voltage is necessary – 5 V and 200 mA, which is provided by the power supply block 7.

3. TECHNICAL SPECIFICATION

The used sensor is type OMV 7620 [4] of the American company OmniVision. It consists of 640 x 480 sensitive elements sizing 7,7 x 7,6 μm. The analogue processor built in it directly to the photosensitive area is able automatically to choose the time for exposition in the interval of 4 ms to 50 ms. On this way a large dynamic diapason of work against the incoming light is provided. The minimal light that can be registered is 0,5 lux which is much less than the real values in real conditions.

The light beam dimensions are: width 1 mm and height 20 mm [5]. In the screen surface the beam movement is limited horizontally to 70 mm. On Fig. 2 is shown the geometrical interposition of the screen with projected on it light beam, the projecting objective and the photosensitive element.

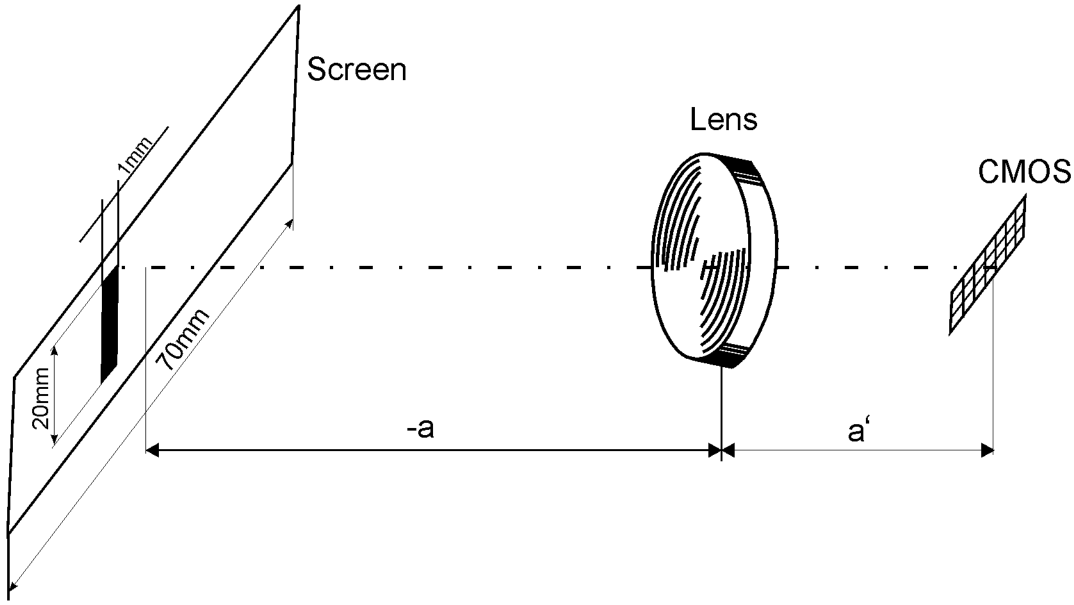

Fig. 2. Geometrical interposition of the screen, the objective and the sensor

The screen and CMOS sensor are optically conjugation and in the horizontal plane for optical magnification it can be written the following:

$$\beta = \frac{Y'}{Y} = \frac{W_{cmos}}{W_{screen}} = \frac{4,87}{70} = 0,07^{x} \ ,$$

where Y' – the size of the image on the sensor, Y – the size of the object, in this case the screen in horizontal plane; W_{cmos} – width of the sensitive area of the sensor; W_{screen} – geometrical size of the screen.

This optical magnification is reached through selection of the sizes a and a'. At such optical magnification the screen size is fragmented to 640 elements and the light beam takes 1/70 part of it or 9,15 elements. In this way on the photosensitive area of the sensor there always will be large number of separate lighted elements, which guarantees the obtaining of reliable electrical signal for further processing.

The resolution capacity of the optic-electronic device will be dependent on the number of lighted elements as well as on the used processing algorithm. If it is used digital reading of the number of the element on which the middle of the light spot is, we will get:

$$\delta = \frac{W_{screen}}{N_{cmos}} = \frac{70}{640} = 0,1 \text{ mm} \ ,$$

where W_{screen} – geometrical dimension of the screen, $N_{\underline{cmos}}$ – total number of sensitive elements of the sensor in horizontal position.

Resolution capacity δ = 0,1 mm is sufficient for practical using [6].

3. PROCESSING ALGORITHM

In parallel 8-bit code the signal from each sensitive element goes into digital processing electronic part where the number of the lighted element is determinated. The order of the operations is the following:

1. For the value of the digital code of the element the relation is checked: $E_{i,j} \geq 128$, where $E_{i,j}$ – the value of the signal of the element of i-row and j-column of the photosensitive matrix
2. If the condition 1 is fulfilled, in a register the number of the element and of the row is memorized.
3. This process is repeated for the following rows and the number of the elements which meet the condition 1 is added in the register of the previous number.
4. After at the end of the sequence the last element also appears, the average value on rows of the is received
5. To the received result 4 numbers are added since the centre is halve-width of the light spot displaced.
6. The average value of several consecutive sequences are calculated.
7. Through start-stop impulses the result is packed to be sent through RS canal to the personal computer.

4. CONCLUSSION

Offering technical solution for booking geomagnetic field permits working in automatic regime with high accurately. Using CMOS matrices fotorecevier dives possibility for decreasing devices dimension.

Coming impending is experimental check of functional devices perimeters.

References:

1. Мардиросян, Г. Устройство за автоматична цифрова регистрация на параметрите на геомагнитното поле – рег. № 106992/ 12.08.2002. Официален бюлетин на Патентно ведомство на Република България, № 2/2003, стр. 42.
2. Мардиросян, Г. Оптимизационен анализ на цифровата регистрация на параметрите на геомагнитното поле. Годишник на Минно-геоложки университет ”Св. Ив. Рилски”, том 47, свитък 1, София, 2004, стр. 279 – 282.
3. OMV7620 Product Specifications – REV 0.9 (10/19/99) OmniVision Technologies ING.
4. SPARTAN-II FPGA Family Functional Description – REV 2.1 (01/03/01) XILINX