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Interference light filter shifting device for the EMO-5 satellite photometric system

Nencho P. Petkov

Space Research Institute, Bulgarian Academy of Sciences, Sofia

In satellite photometric equipment for studies of weak optical emissions interference light filters and common photoconverter and measurement track are used to separate the spectral lines measured by illumination intensity [1, 2, 3, 4]. This combination substantially decreases size, weight and power consumption, but requires mechanical shifting of the different light filters in front of the photoconverter. To meet the requirements of a specified law of motion of the light filters, a discrete drive by step drivers is most frequently used.

Two kinematic chains with discrete drive are used in the EMO-5 photometric system, working as part of the complex of scientific equipment aboard the INTERCOSMOS-BULGARIA-1300 satellite. They provide for measurement the illumination intensity in 6 spectral lines, periodical calibration at flight time, and obtaining of images of illuminated areas in one spectral line. We shall consider here the specifics and shall describe the principle of control of the interference light filter shifting in the EMO-5 photometric system.

The block diagram of the device for shifting the interference light filters in the EMO-5 system is shown in Fig. 1. The following conditions have been observed in this design: provision of 8 measurement positions (6 spectral lines, reference source for calibration and position for drift measurement of the photoconverter); exact setting of each cyclically repeated position in front of the photoconverter for a specified time period; reliable operation of the mobile parts in vacuum and within the temperature range of -20 to +50° C, small size, low weight and power consumption; objective control over the measured positions.

The six interference light filters, the reference source and the position for drift measurements are situated evenly along a rotating disc (F VV). The rotation of FVV is effected by a discrete drive with a step driver and is synchronized by 1 s pulses (SP) from the board system for universal time. In order to provide the exact determination of each position of FVV, the step driver with a reductor (SMR) is controlled by the position of the driven shaft via position keys (PS) of optoelectron type. Pulses are produced for each measurement position (FP) and for the beginning of each new cycle (CD) of the FVV rotation, with respective duration of τ_{FP} and c_D.

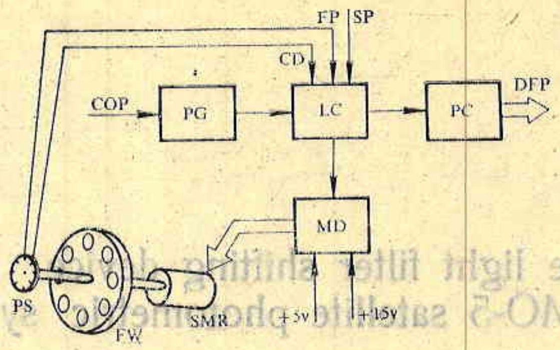

Fig. 1

The necessary time period Δt_M for the measurement of each position is determined by the requirements of the photoconverter. For a time Δt_M, FVV should be reliably fixed in one of the eight measurement positions, and then shifted to the next one. Due to the motion of FVV in one direction, the control block (MD) of SMR is of the irreversible type. The block for logical control of the motion (LC) provides the time period Δt_M, as well as the period Δt_D, allowing the FVV motion in dependence on the PS state. The step driver makes N steps in order to shift FVV at an angle θ_{FP} to the next position:

(1) $$N = \frac{\theta_{FP}}{\pi K_i} P,$$

where K_i is the coefficient of reduction; P — parameter of the step driver, depending on the type and commutation of its wiring.

The precision of fixing FVV in a given position is $\theta_{FP} < K_i \frac{\pi}{p}$. An additional signal is introduced into the system so as to forbid the FVV motion from the comparator for optical protection (COP) of the entire photometric track of the EMO-5 system. When no signal is supplied by COP, the pulses from the output of a pulse generator (PG) enter LC. The information (DFP) on the position of FVV enters the telemetric system as a 4-order parallel code from the output of a counter for interference light filter positions (PC).

The logics of motion control may be illustrated with Fig. 2. The synchropulses SP with period T_{SP} are supplied to a frequency divider (FD) and a drive timer (T_1). Along with this they set up the monovibrator T_3 into starting position allowing the pulses from PG to enter via coincidence circuit (G_2) to MD so as to drive the step driver (SM). After T_1 the period is divided into time periods Δt_M and Δt_D, while Δt_D is computed with supplementary value with regard to the time necessary for the FVV motion between two adjacent positions. When FVV reaches a given position via the coincidence circuit (G_1), a pulse of duration τ_{FP} enters T_3 and drives it out of the starting position. A time period Δt_P is produced to forbid motion, where $\Delta t_P > \Delta t_M$. Simultaneously, a pulse of duration τ_{FP} enters PC to indicate the given position of FVV, and the annuling of PC is effected by a CD pulse for the beginning of the rotation cycle. The sequential synchropulse with a period $2T_{SP}=\Delta t_M+\Delta t_D$ returns T_3 to starting position. (T_2) monovibrator is incorporated also in LC, producing a pulse of duration 100 ns.

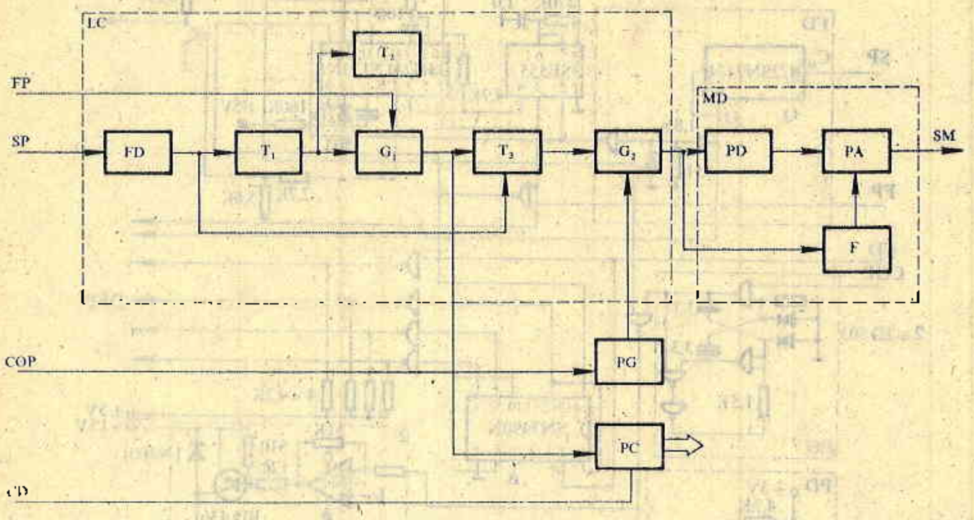

Fig. 2

The control block (MD) of the driver contains pulse distributor (PD), power amplifier (PA) and control circuit (F) for the current via SM wirings. PD transforms a unitary code into a m-phase system of rectangular pulses, where m is the number of wire commutation cycles, and F provides low consumption for time Δt_M.

The block electrical circuit of motion control of the interference filters into the photometric EMO-5 system is shown in Fig. 3. At $T_{SP}=1$ s, T_1 (SE555) provides time periods $\Delta t_D=0,5$ s and $\Delta t_M=1,5$ s with 2% precision. The monovibrators T_2 and T_3 are implemented on integral circuits SN54LS123N. No firm requirements with regard to the pulse generator (SN5400N) exist. The generator operates on frequency of 100 Hz. The pulse distributor (SN5474N) is of the irreversible type and transforms a unitary code into a 4-phase system of rectangular pulses. The power amplifier is unipolar, irreversible with transistor-diode keys (4×KFY18, 8×2D51OA, 2×SN75450). The current through the step driver wiring is regulated via transistor (BD 436), controlled by an inverting amplifier.

A step driver of the CDA-15 type with two phases, active rotor and a single step of 15° is used into the motion device for the interference light filters. In order to safeguard its performance in space vacuum its bearings are replaced by the vacuum type TU370060 58-73, while the carriers of the different wires are produced from caprolon plastic. The reductor has a coefficient of reduction $k=1:10$, the driving wheel is made of steel brand 45. The driven wheel made of caprolon carries the light filters. The overall weight of the device is 290 g and the power consumption <2 Wt.

The device for shifting the interference light filters has successfully passed all the tests and operated within the EMO-5 photometric system aboard the

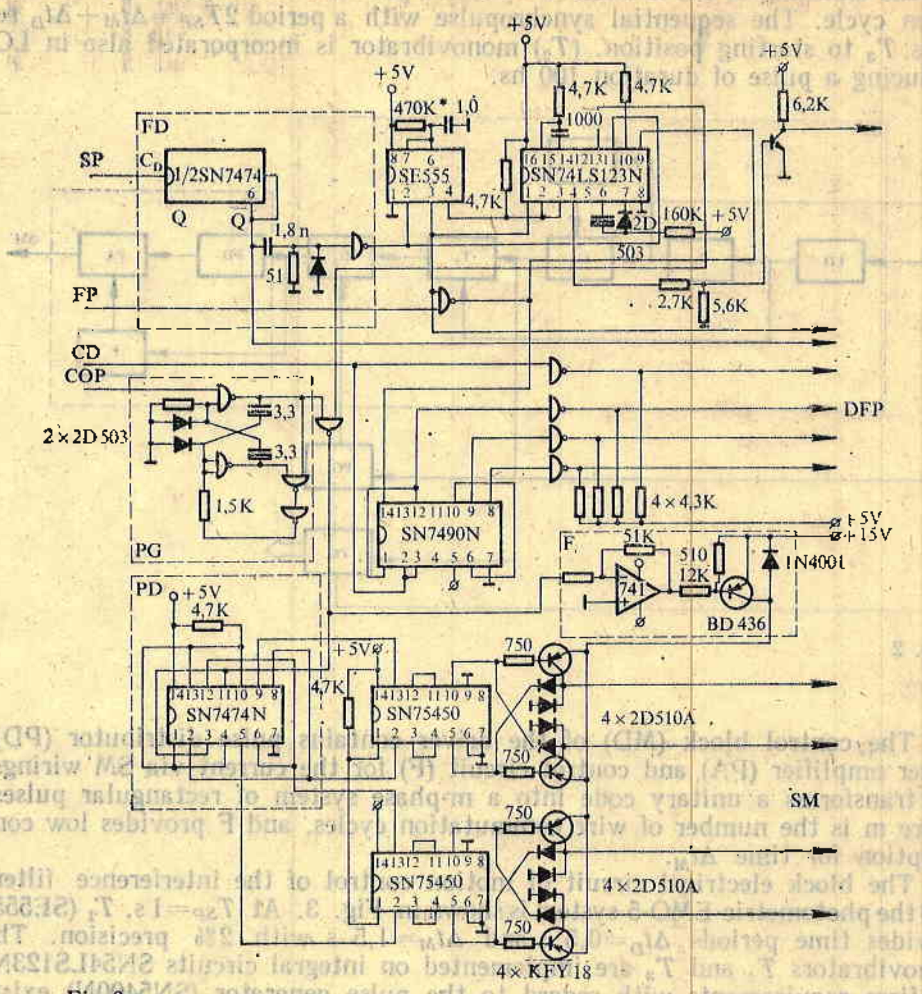

Fig 3

INTERCOSMOS-BULGARIA-1300 satellite. For one year, more than 300 hours of active operation can be reported for the EMO-5 system.

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Устройство для перемещения интерференционных светофильтров в спутниковой фотометрической системе ЭМО—5

Н. П. Петков

(Резюме)

Рассмотрены характерные особенности интерференционных светофильтров и описан принцип управления их перемещением в фотометрической системе ЭМО — 5, участвующей в комплексе научной аппаратуры спутника Интеркосмос — Болгария — 1300. Даны блок-схема и короткие описания технико-эксплуатационных характеристик основных блоков. Показана и прокомментирована логика управления движения.