PULSE-COUNTING PHOTOMETER AT THE SKALNATÉ PLESO OBSERVATORY

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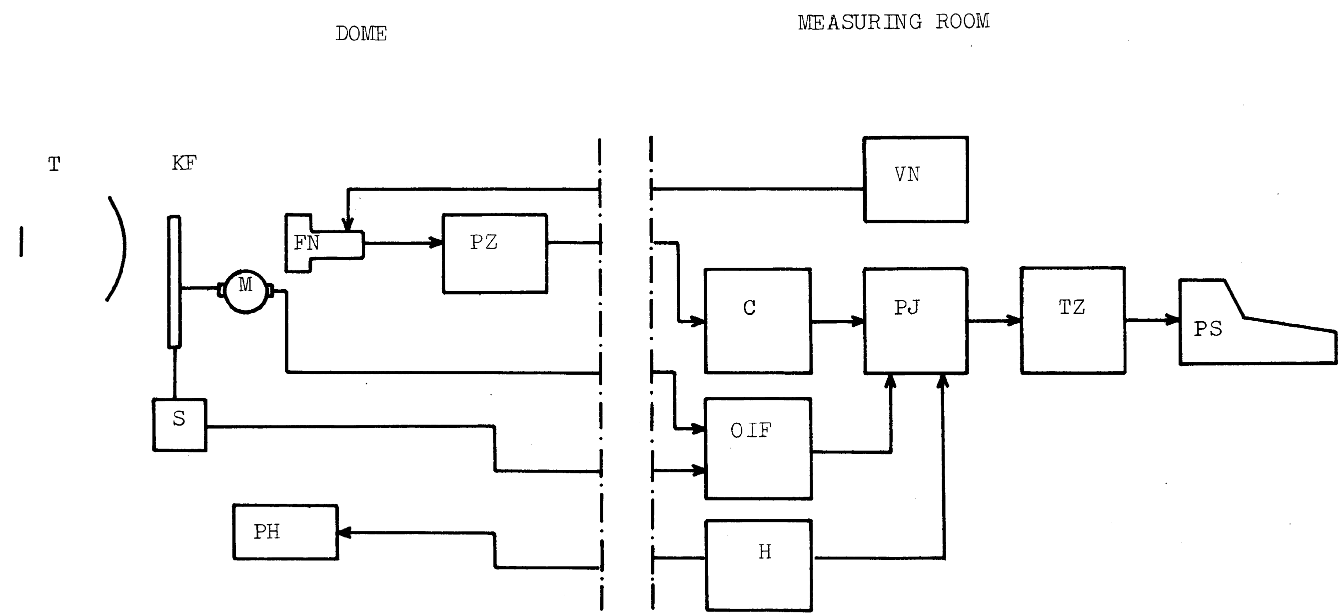
ABSTRACT. A digital semi-automatic measuring system of the photoelectric photometer of the 0.6 m telescope at the Skalnaté Pleso Observatory is described.

ФОТОМЕТР ОСНОВАННЫЙ НА ПРИНЦИПЕ СЧИТЫВАНИЯ ИМПУЛЬСОВ. Описывается цифровая полуавтоматическая измерительная система 0.6 м телескопа обсерватории Скалнате Плесо.

FOTOELEKTRICKÝ FOTOMETER S POČÍTANÍM PULZOV. Opisuje sa číslicový poloautomatický merací systém 0.6 m ďalekohľadu na observatóriu Skalnaté Pleso.

1. INTRODUCTION

In 1964, the then modern photoelectric measuring system with recording and control devices, based on second-generation electronic components /Horák et al., 1976/, began to be used at the observatory of the Astronomical Insti-



T - Telescope
S - Filter position indicator
KF - Filter wheel
M - Filter drive
FN - Fotomultiplier
PZ - Preamplifier
PH - Secondary clock

VN - High voltage supply
C - Counter
PJ - Control /Program/ unit
TZ - Printer control
PS - Typewriter
OIF - Filter control and indication
H - Main clock

Fig. 1. Overall block diagram of measuring system

tute of the Slovak Academy of Sciences in Skalnaté Pleso. Over a period of 10 years, this system was used to obtain a large number of precise observations of variable stars. Due to the lack of spare parts, the system was discarded and temporarily replaced with an analogue recorder at the output. In 1980, the Institute began to cooperate with the Department of Radio Electronics of the Slovak Technical University in Bratislava, and the result was a measuring system based on the pulse-counting technique. This system began to operate in 1983. It has been used to obtain a number of photoelectric observations of variable and peculiar stars, the results of which have been published, e.g., in papers by Bakoš and Tremko /1984/, Chochol et al. /1985/; further reports are being prepared for press. The purpose of this paper is to present a brief technical description of the architecture of the system as a whole and the designs of some of its parts.

2. PHILOSOPHY AND ARCHITECTURE OF THE SYSTEM

The system was required to have the possibility of interactive control of the observation process. With a view to the mechanical design of the 0.6 m telescope with no positional sensors, the system was requred to operate semi-automatically. The output and recording of the information had to be at last at the level of the system used in the years 1964 - 1974. It was considered most effective to make use of components currentavailable on the market. The use of the optical and mechanical parts of the original photoelectric photometer with innovated electronics was also considered. The new system was thus to have consisted of the following parts:

a, innovated photometer,

b, detection electronics /newly developed, commercially available parts/,

c, control unit /newly developed/,

d, recording unit /commercially avialable parts, some modifications/.

The pulse-counting technique was chaosen for the detection; the recording unit was dependent on the possibility of acquiring memory equipment adn, therefore, a type-writer output had to be adopted. The block diagram is in Fig.1.

3. DESCRIPTION OF THE INDIVIDUAL PARTS

3.1. Photometer

The photoelectric photometer is installed in the Cassegrain focus, f = 7 550 mm, of the 0.6 m telescope. This is a one-channel photometer with a filter disk with ten orifices. It has been modernized by adding a new sensor of the filter position, a filter position indicator and controls of the filter disk.

The filter position sensor operates on the photoelectric principle. The position of the inserted filter is determined by photo transistors which detect the light of LED-type diodes according to the orifices in the filter disk. The output signal in BCD code from the sensor is processed in the position indicator, whose display shows the number of the filter inserted into the optical path of the photometer. This information is displayed on the photometer itself as well as in the measuring room. The filter disk is controlled manually by means of a push button which switches on the drive. The signal from the position indicator is also fed to the control unit which processes it.

3.2 Detection System

The detection system consists of a photomultiplier, a pre-amplifier and a pulse counter. In this photometer a dynode EMI 6256 B type photomultiplier has been used. A signal of the photomultiplier consists of pulses whose number is directly proportional to the number of photons incident at the photo cathode. As regard photoelectric photometry, the useful information contained in this signal is the number of pulses per unit time.

The pre-amplifier is a part of the measuring system whose properties and quality have the largest effect on the quality of the system. The principal function of the pre-amplitier is to generate and amplify useful pulses which can be reliably processed by the pulse counter.

The pre-amplifier consists of three parts, the amplifier, discriminator and pulse shaper, as shown in Fig. 2. With regard to preserving the useful information it does not matter if the shape of the pulses is distorted after passing through the amplifier, but it is important that one pulse from the photomultiplier output correspond to just one amplified pulse at the amplifier output. The pulse discriminator is designed to select the useful signal from the signal as a whole and, with the aid of the selected discrimination levels, to suppress the noise as much as possible. An important factor in suppressing the noise pulses is the choice of the threshold voltage for each type or for the individual photomultiplier. This is based on the amplitude distribution of the noise pulses, whose characteristic is shown in Fig. 3. The relevant parameter is the supply voltage of the photo cathode, U_C. The typical amplitude distribution function fo the noise pulses of the photomultiplier suitable for counting pulses is characterized by the so-called one-electron minimum /Curve a in Fig. 3/ in which it is advatageous to chose the threshold voltage of the pulse discriminator. In some photomultipliers, the exponential branch above this minimum prevails /Curve b in Fig. 3/. These photomultipliers are not suitable for the pulse-counting technique. An important factor is the supply voltage of the photocathode, U_C. The dependence of the number of noise pulses of the photomultiplier on the value of U_C is shown in Fig. 4. The number of noise pulses within a particular interval of values

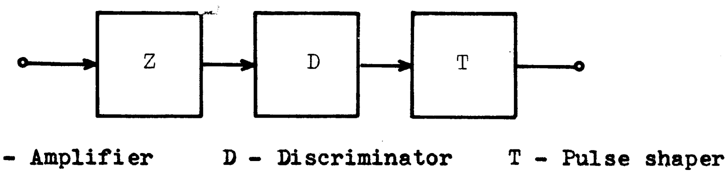


Fig. 2. Preamplifier block diagram

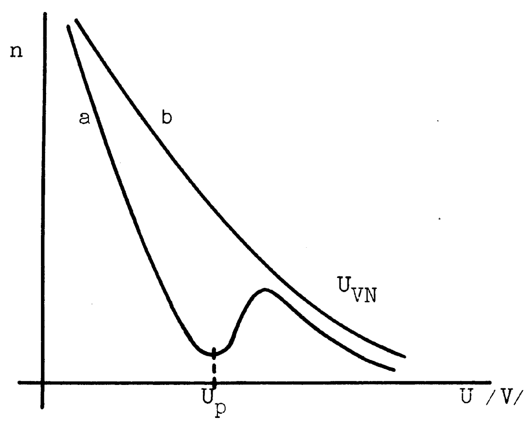


Fig. 3. Amplitude distribution of noise pulses

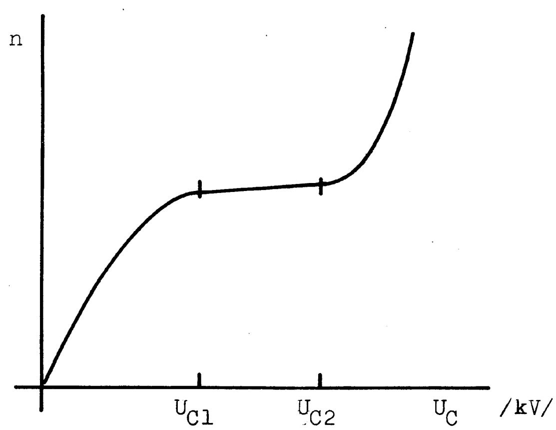


Fig. 4. Dependence of noise pulse number - cathode voltage

U_{C1}; U_{C2} varies only gradually and it is, therefore, convenient to chose the working value U_C in the middle of this interval.

In this system, the pulse counter is a product of TESLA, N.C. Brno, the "Universal Counter BM 465", which provides accurate frequency measurements up to 50 MHz of signals with amplitudes larger than 50 mV. For the purposes of photoelectric photometry, the counter operates in the pulse-counting mode with an external time base and integration perods of 1 and 10 s. After minor modifications, this counter has proved to be fully satisfactory for the photoelectric measurements made with the 0.6 m telescope.

3.3 Control Unit

The inputs of all parts of the system are concentrated in the programming unit. This unit program-controls the whole measuring process. It processes al the measured and auxiliary date in the require time relations, and documents them with the aid of the peripheral device. Its block diagram is shown in Fig. 5. A part of the programming unit is a ROM-type fixed program store in which the programs of the whole measuring system are loaded. This unit is used to choose the integration period, the number of repeated measurements of the object /2, 5, 10, 20 and 50 measurements/ and to trigger the whole measuring cycle. The object can also be coded by setting any four-digit number. A part of the unit are also decoders of auxiliary data /filter number, time data/ from the BCD code to the 1242 code in which the record control unit operates. The time signal from an external clock is fed in serial code which is transformed to parallel form.

The control unit cooperates with the time data source, i.e. a digital, programmable, crystal-controlled ASTRO - 01 clock. This clock was manufactured by the Group of Technical Development of the Astronomical Institute. The clock display indicates the time in classical form /hours, minutes, seconds/, and, simultaneously, in decimal fractions of a day. The data on the display can be programmed and, if necessary, stopped, whereas the time counting block continues to operate. In the case of an electric mains failure, the clock switches automatically to auxiliary battery supply. The clock oscillator is temperature controlled which quarantees its accuracy /10^{-8}/. A part of the clock is a time data transmitter which combines the time information of the number of hours, minutes and seconds at the input. After this signal has been processed by the logic circuits, the time data are transformed to a wide modulated serial code which can be fed to the control unit by a twin cable and to the repeater clock in the observatory dome. This system replaces a 45-strand cable which would have to be used for the classical transmission of the complete time signal.

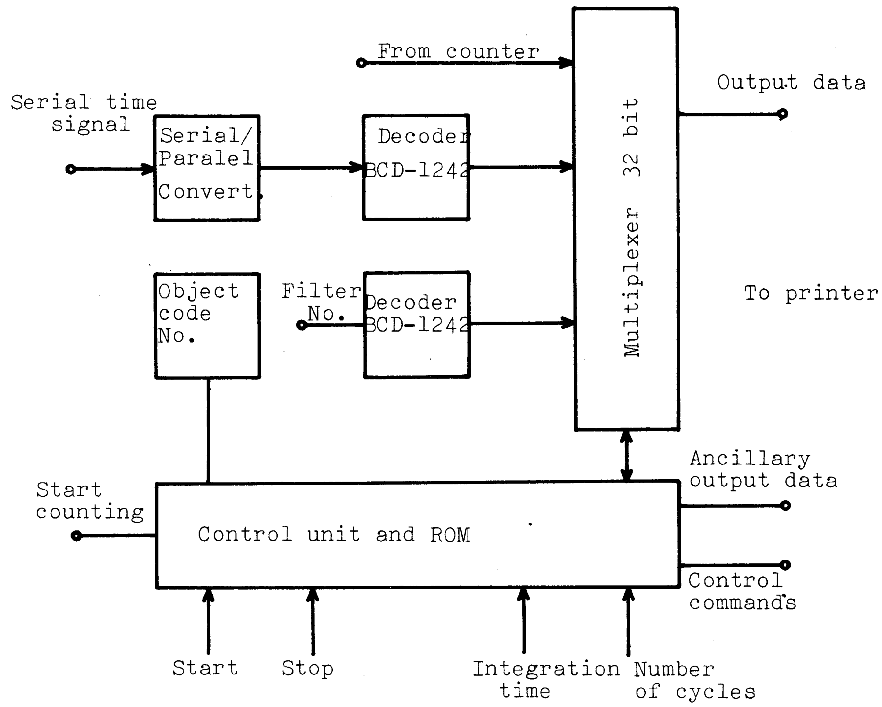


Fig. 5. Block diagram of program unit

3.4. Recording Unit

The recording unit consists of the peripheral equipment of the measuring system and its function is to document the measured data. In this paricular case, a commercially produced BP 4653 recorder of TESLA, N.C., Brno has been use. Since this unit must cooperate with the programming unit, the block was modified to enable:

- remote switching of the record,
- remote control of the printing colour,
- remote control of carriage return,
- control of printing decimal points and printing format.

Three types of data are recorded in each series of measurements: heading, time data and the number of measured pulses. Each of them is recorded as an eight-digit figure. The heading is in red print at the beginning of the measurement cycle. The first four digits represent the code of the measured object, the next two give the total number of measurements in the cycle, the last but one digit gives the number of the filter inserted into the optical path, and the last digit of the heading gives the integration period. The time is printed red at the beginning of the cycle immediately following the heading and also after every fifth measurement. The number of pulses from the photomultiplier is recorded in black immediately after the integration has been terminated.

4. CONCLUSION

The measuring system described is designed for photoelectric observation in a semi-automatic mode. The digital record of the signal has eliminated errors of a subjective nature in processing the observations and has accelerated the subsequent processing considerably. This system has replaced in full the preceding system with the analogue record.

During test measurements, the dead time of the measuring system was determined. The method, described by Hall and Genet /1982/ yielded the value $\delta = 9.75 \times 10^{-8}$ s. The system is able to measure the brightness of stars down to stellar magnitude 13 in the UBV photometric system.

An improved system which, apart from a higher standard of automation of the measuring process, also enables the observations to be recorded on magnetic tape, is now being put into operation at the Skalnaté Pleso Observatory.

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