A SIMPLE METEOROLOGICAL SYSTEM FOR SUPPORTING OPTICAL MEASUREMENTS IN THE ATMOSPHERE

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A meteorological system for measuring the average values of the wind velocity and temperature at three spatially separated points is described. This system can perform measurements in both an autonomous regime and a computer-controlled automatic regime. The system design followed the 3 M module of the CAMAC standard.

The purpose of the meteorological system is to perform accurate measurements of the average temperature and wind velocity at spatially separated points. It makes it possible to evaluate the turbulent and refraction properties of the atmosphere, which are necessary for monitoring the conditions of propagation of optical radiation.[1–3]

The measurements are performed in an autonomous or a computer-controlled automatic regime. In this case the computer serves as an internal processor, which processes signals from sensor only when averaging has been completed. This makes it possible to relieve the computer from performing routine data-acquisition operations and to increase the accuracy of measurements of the temperatures $\bar{T}_i$ and their gradients $\bar{T}_{ik} = \bar{T}_i - \bar{T}_k$, and to simplify the instrumentation for the multichannel measurements scheme. The simplification is also achieved owing to the fact that the physical parameters – the temperature $\bar{T}$ and the wind velocity v – are converted by primary sensor into the repetition frequency of the counted pulses. As a result the meteorological system consist of a program-controlled six-channel frequency meter with a general control unit and a timer, which sets the averaging and indication time and the spacing of the measurement cycles (Fig. 1).

An M25 anemometer is used as an external sensor of the wind velocity v. To increase the initial sensitivity the mechanical unit forming the anemometer pulses is replaced with an optoelectronic unit. The sensor forms a pulse-modulated current signal with a carrying frequency $f_1 \simeq 300$ kHz and a degree of modulation $M = 0.5$ by pulses from the optical sensor, whose repetition frequency $f_v \sim \bar{V}$. The current output through a decoupling filter is loaded on a connecting cable with length $l = 80$ m feeding the sensor.

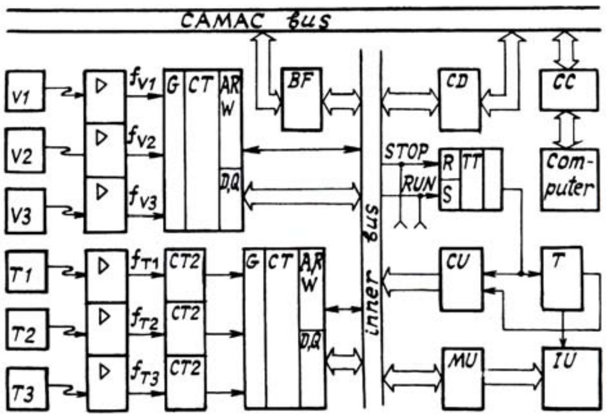

FIG. 1. Structural layout of the meteorological system. V1-V3, T1-T3 are wind-velocity and temperature sensors; CD – counter-divider; CT – programmable timer; BF – highway bus former; CD – CAMAC command decoder; CU – control and synchronization unit; IU – indication unit; T – timer; CC – crate controller.

The experimental temperature sensor is a self-excited oscillator ($f_0 = 5$ MHz) with a quartz resonator in a circuit loop.[4] A thermal converter of this type has a higher conversion transconductance and lower nonlinearity than the widely employed copper and platinum resistance thermometers.[5] On the one hand the linearity of the temperature-frequency characteristic of a sensor of the type RTs 2.821.016 simplifies the calibration of the thermometer and reduces it to calibration of two reference points in the autonomous operating regime. On the other hand he same characteristic is, to a high degree of accuracy and in wider temperature interval, quadratic curve.[6] Its coefficients are stored in a external memory unit of the computer. For this reason, in the automatic regime with an external computer the meteorological system provides more accurate measurements of the average temperature and its gradient and a more complicated calibration curve than in autonomous regime. To increase the accuracy the cascade self-excited oscillator consumes power $P_e \simeq 150$ μW with a supply voltage $E_c = 3.3$ V. Power $P_V \simeq 1.8$ μW is dissipated in the oscillator circuit with aspiration of the thermal converter and oscillator as a whole. The rated overheating of the sensor is $\Delta T_n < 0.002$ K (Ref. 6). The output signal of the sensor with amplitude ≃ 20 mV on a matched load $R_L = 50\ \Omega$ is fed, also along a feed cable with decoupling filters at the receiving and transmitting ends, into the input of one of three resonance amplifiers, which increase the signal/noise ratio at the input of the frequency meter.

The output signal of the wind-velocity sensor is fed into the input the amplitude detector with a low-frequency *RC* filter at the output. The filter constant $\tau_v \simeq 15$ μs, which gives an upper limit of the wind velocity $\bar{V}_{max} = 30$ m/s. The input former forms from the output pulses of the amplifiers and detectors countable pulses of the *TTL* level.

The autonomous operating regime of the meteorological system is set automatically when the power supply is switched on. In this regime the output *TTL* pulses from three temperature sensors $\bar{T}_i$ and three wind-velocity sensors $\bar{V}_i$ are read in a binary-decimal code by six summing counters based on a 580V153 controllable timer. The accumulation time $t_{acc} = 120$–1200 s is set by the standard quartz oscillator. The results of accumulation from the output of the counters – the number of pulses over the time τ_{acc} – is indicated through the internal memory of the system along the channels with a period of ~ 2.4 s. The actual values of the velocity and the temperature are determined based on the indications of the indicators with the help of the calibration curves for the corresponding sensor. The content of the memory is freshed at the end of each cycle of measurements.

In the automatic regime, under the control of an external computer, the counters of the frequency meter sum the pulses in binary code. The true values to the velocity $\bar{V}_i$ and the temperature $\bar{T}_i$ are calculated by the computer from the results of the accumulation of pulses in the registers of the frequency meter. In the calculations the temperature-sensitivity characteristic of the thermal converters is approximated by a quadratic curve.[6] The values of the coefficients of the curve are determined when the sensor are calibrated and stored in the external memory of the computer. The results of calculation are fed into the memory of the meteorological system for successive indication along the channels without additional referral to the computer.

To calculate the Richardson number R_i and the structure constant of the refractive index C_n^2 the meteorological system measures the modulus of the gradients ΔT_{ik} (Ref. 2). In this case the counted pulses from the sensors $\bar{T}_i$ are fed into the inputs of the logical circuits forming the difference frequencies $\Delta f_{ik} = f_i - f_k$; a signal with the reference frequency $f_0 = 5.0$ MHz is fed from the output of the quartz oscillator to the second inputs of the logical circuits.[7] This increases the resolution of the system and expands the range of measured values of the gradients ΔT_{ik}.

The meteorological system is constructed following the 3M module of the CAMAC standard and is controlled by the standard collection of CAMAC commands, including processing of call signals generated by the module at the end of measurements cycle.[8]

Based on the results of the tests, when the meteorological parameters were determined by the system and the standard temperature and wind-velocity sensors, the range of the measured values of the temperature was equal to (–10 – 50)°C±0,03°C and for the temperature gradients the range was ±2.5°C with an rms resolution in the differential scheme of ±0.015°C with $\tau_{acc} = 300$ s; the range of values of the wind velocity was (0.6–30) m/s with the rated error of the M25 anemometer. The final check of the meteorological system was made under real atmospheric conditions, when the values of the structure constant of the fluctuations of the refractive index C_n^2 were calculated from simultaneous measurements of the average meteorological parameters and the spectral density of fluctuations of the air temperature.[2] The results of the calculation of the diurnal variation of C_n^2 are in satisfactory agreement with one another.

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