This article presents a measurement information system for a tunable laser for lidar: the tuning and wavelength stabilization functions for laser oscillators, the data collection module, and the wavelength sensor. Control is implemented by software running on an IBM compatible PC.

The authors of [1] considered using the method of resonance scattering of laser radiation to determine the concentration of N$_2^+$ molecular ions formed by radioactive radiation in the atmosphere. It has been shown that of the transitions of N$_2^+$ ions, there is a preference for transitions in the first negative system with oscillating quantum numbers $a^I = a^{II} = 0$, and the radiation has wavelength 391.8 nm. It is weakly absorbed by atmospheric components, and the transition is characterized by the short lifetime of the excited state (or the order of $10^{-7}$ sec), and large oscillations. As a result, the reverse scattering cross-section is large: $1.7 \times 10^{-14}$ sm$^2$/sr$^4$ for $T = 200$ K, according to the data of [1]. Lidar — which is used to determine the concentration of N$_2^+$ in the atmosphere — can be based on a saphire-titanium laser (Al$_2$O$_3$:Ti$^{3+}$ using the second harmonic; this laser has a broad tuning range: 0.64-1.1 $\mu$m, i.e., 0.32-0.55 $\mu$m for the second harmonic). Here the most important problem is tuning and stabilization of the wavelength of the saphire-titanium laser driver.

Modern methods impose stringent constraints on the parameters of tunable lasers. In order to assure proper control of the radiation parameters of a laser, we constructed a measurement information system that implements the control function largely in software written for an IBM compatible PC. Our approach enables stepwise development of a system from an elementary, intermediate, but logically complete base to a more complex system that is easily modified to account for concrete requirements. Our system is based on modules for data collection and control, as well as a wavelength sensor. The sensor for determining radiation wavelength is an optical system based on the scheme shown in Fig. 1.

Radiation from the source 1 passes through lens system 2, impinging on the diffraction grating of the Fabry—Perot interferometer 3. The diffraction grating generates a diffraction pattern of alternating light and dark rings in the plane 4. Information about the rings is obtained with a position sensitive sensor, which is mounted on a movable platform 5. The platform is moved by the stepping drive 6. The central element of the sensor is the photosensitive element 7.

Four identical photosensitive zones are deposited on a single crystalline substrate; each of these generates an electrical signal proportional to the amount of incident light. The signal from the sensor is the difference of the signal between two zones. This design makes it possible to reduce the effect of extraneous illumination.

A block diagram for the data collection and control module is shown in Fig. 2. A distinguishing feature of the module is the presence of a standard parallel port, like the parallel interface on an IBM compatible PC. This direct connection of one or more such modules to a controlling PC. The exchange of data between external devices and the the computer on the eight-bit bus proceeds by writing standard commands into registers and reading data from registers.

During operation as an information measurement system, the following functions are executed by the module:

- transformation of the signal from the sensor into a 10-bit binary code, storage of the information, and transmission to the computer;
- control of the operation of three ShchDR-711 stepping drives;
- input and stroage of digital information from the end switches on the stepping drives;
- selection of one of eight analog input channels.

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Two parameters must be known to determine the wavelength of radiation — the geometric dimensions of the optical system and the diameter of the interference rings. The geometry of the optical system is determined during calibration: "standard" radiation from a stabilized laser is applied to the interferometer, and the interference pattern that is formed is scanned. The number of steps between the interference lines is determined, and this is used to determined the diameter of the interference rings. The same measurement is then performed for radiation from the tunable laser. Knowing the wavelength of the standard laser, we can use the known diameters of the "standard" and measured rings to compute the wavelength of the tunable laser from the following relations:

$$\lambda_s (m_s + e_s) = \lambda_x (m_x + e_x),$$

where $m_s$, $e_s$, $m_x$, and $e_x$ are the integral and fractional parts of the interference for the wavelengths $\lambda_s$ and $\lambda_x$.

$$e_{s,x} = [(q-1)D_p^2 - (p-1)D_q^2] / (D_q^2 - D_p^2);$$

$D_p$ and $D_q$ are the the diameters of the $p$-th and $q$-th interference rings.

In subsequent measurements it is only necessary to scan the interference patterns and compute the wavelength of the tunable laser, since we know the parameters of the optical system.

The measurement information system was tested with lasers radiating in the range of 0.64-1.1 $\mu$m. The maximum resolution of the system is 0.01 $\mu$m. The scanning time at maximum resolution is 50 sec, with a continuous scan 2 minutes long.