RECORDING AND REMOTE CONTROL SYSTEMS OF A COMPACT AEROSOL LIDAR

A.P. Rostov

*Institute of Atmospheric Optics,
Siberian Branch of the Russian Academy of Sciences, Tomsk*
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A modification to the design of recording and remote control systems of a compact aerosol lidar is proposed.

At present the LOZA–3 and LOZA–5 aerosol lidars are mounted on chassis and servosystems of various radars. They are large and massive devices transported by a truck or trailer. Design of these lidars is such that in the regime of their operation the temperature inside the cabine is several degrees higher than outside. Since a modern lidar, as a rule, has a modern computer as recording and control unit, its operation becomes problematic at negative temperatures. It is difficult and harmful for experimenter to work under such conditions, and it is practically impossible to perform routine measurements.

Taking into account the preceding, the author proposed an instrumentation program complex for compact aerosol lidar whose opto–mechanical train was developed at the Institute of Atmospheric Optics of the Siberian Branch of the Russian Academy of Sciences, Tomsk. It was capable of remote recording and controlling the lidar at a distance of 500 m from a computer. A concept which had already been checked for an infrared lidar in vertical sounding of tropospheric ozone[1] was applied to the transmission of information while a microcontroller built around a monocrystal microcomputer was specially developed for transmission and reception of instructions and control of a servosystem. A block diagram of recording and control systems is shown in Figs. 1 and 2, respectively.

Lidar specifications

Maximum signal amplitude	3 V
Frequency range of input signal	(0–7.5) MHz
Dynamic range of input signal	60 dB
Input resistance	50 Ω
Sampling rate	40 MHz
Maximum frequency of sounding	41 Hz
Frequency stabilization of synchronizer	Crystal control
The number of bits of the ADC	7
Information stored for one shot	8192 words
Type of input timing signal	Light or electric
The number of amplification switching for one sensing step	16
The number of bits of the DAC employed in adjusting to zero	8
Baud rate of modem	5 Mbaud
Coding scheme modem	4/5 BVNM
Communication line of modem	r–f cabel, 50 Ω
Voltage of galvanic decoupling	2 kV
Interface of control channel	RS–232
The number of analog inputs of microcontroller	8
Maximum input voltage	±5 V
The number of analog outputs of microcontroller	2
Maximum output voltage	±10 V
The number of 8–bit input/output ports	4

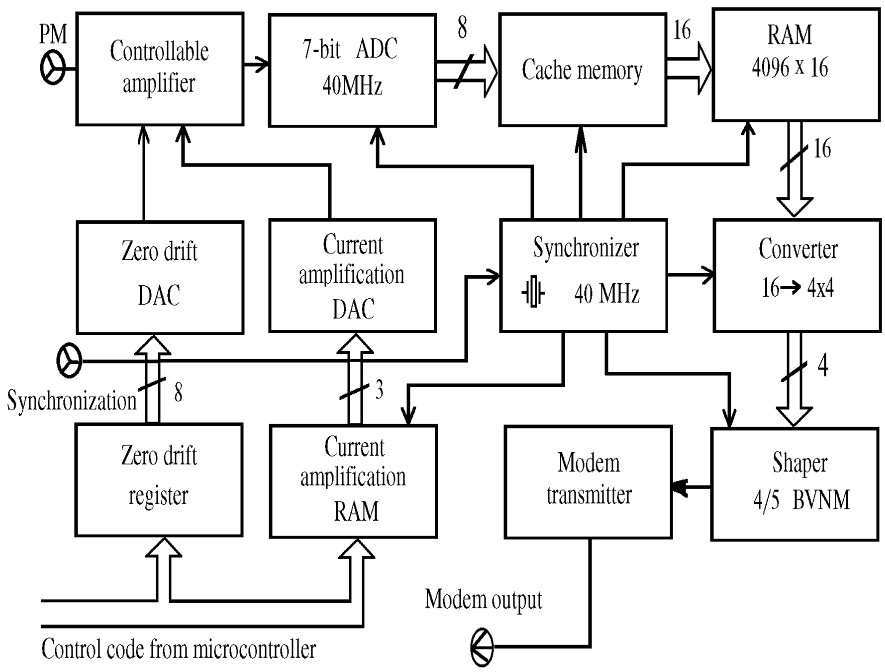

FIG. 1. Block diagram of the system of recording and transmission of information of aerosol lidar.

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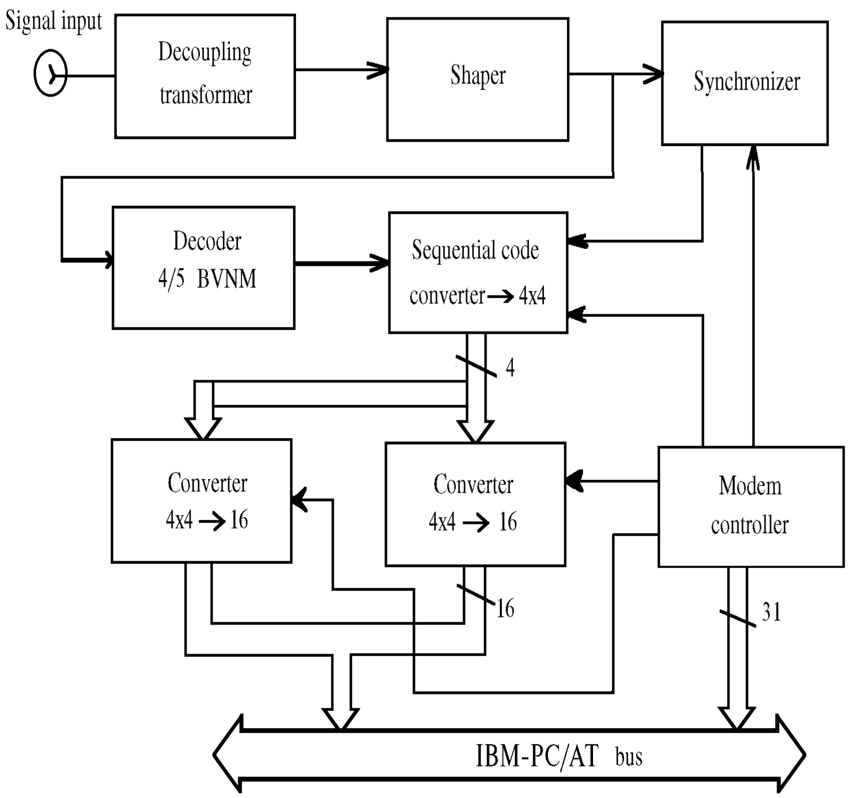

FIG. 2 Block diagram of the modem system built in IBM–PC/AT.

When lidar systems were used for sounding of atmospheric aerosols, it was found that the signal–to–noise ratio at the output from a photomultiplier (PM) amounted to 30 dB at best and usually did not exceed 20 dB. Since for one direction of scanning we rarely perform more than three averaging, a 7–bit ADC will suffice to digitize the echo–signal with an error of 5%. In this case the input signal level must be kept at the center of dynamic range of the ADC.

These requirements were taken into account in the devevoped analog–to–digital train of the recording system of the aerosol lidar.

Now we describe it in more detail. Echo–signal in the form of electric current from the PM is fed into a controllable amplifier. Depending on the code of the current amplifying coefficient, this input amplifier has 8 steps of current transfer ranged from 0.5 to 4. The user preliminarily (before sounding) writes the code of the amplification coefficient into the random–access memory (RAM) being sampled by a strobe counter at the instant of digitization of echo–signal, thereby changing the amplification of the input signal by the required law. Moreover, one more fixed signal of compensation for illumination voltage and zero drift is fed into the amplifier. This signal is formed by a digital–to–analog converter (DAC), which has its buffer register controlled with a microcontroller by operator instructions. From the amplifier output the echo–signal is fed into a 7–bit parallel ADC built around the two large integrated circuits (LSI) of the 1107PV3A ADC. As experiments carried out in the field of developing the ADC for lidars show, this solution has the following advantages over the design of digitization unit built around the monocrystal 8–bit 1107PV2 LSI ADC:

– cumbersome and complex sample–and–hold circuit is eliminated because conversion time does not exceed 10 nsec and bits are not skipped,

– power consumption is three times smaller, and

– noncriticality to voltages of power supply.

Information originating in the ADC in the form of digital 8–bit code (the eighth bit is overflow pointer) enters a cache memory and then is transmitted along the RAM, modem transmitter, communication line, and modem receiver built in the IBM PC/AT. This part of the system was described in more detail in Ref. 1.

We consider the operation of the microcontroller of the lidar now. It is intended to control a servomechanism, temperatures of cooling liquid and system, and voltage of secondary power supply, to receive operator instructions, and to transmit information about the current state of the lidar. The 1816VE31 LIC being analog to the Intel i8031 is used as the central processor of the microcontroller. This is the 8–bit monocrystal microcomputer whose internal performance slightly exceeds a million elementary operations per second. The internal highway is arranged by demultiplexing of signals of microcomputer and consists of address, data, and control buses. Two peripheral programmed adapters (PPA's), RAM, and read–only memory (ROM) with 2 kbyte capacity each are connected to this internal highway. The monocrystal 10–bit 1113PV1 ADC is connected to the port of the 1816VE 31 R1 LIC. The 8→1 590KN6 analog commutator is connected to its input. The main purpose of this ADC with commutator is to digitize analog signals from temperature and voltage pickups and from servomechanism. The RS–232 signal shaper used for communication with console of IBM PC AT/286/386/486 is connected to the series port of the microcomputer. Ports A and B of the first PPA are connected to pickups of position of servomechanisms, and ports A and B of the second PPA serve for generation of analog signals of control by servomechanism. Ports C of the first and second PPA's serve to control the regime of operation of the main signal train of the lidar. Such microprocessor architecture allows us to adapt it to many lidars.

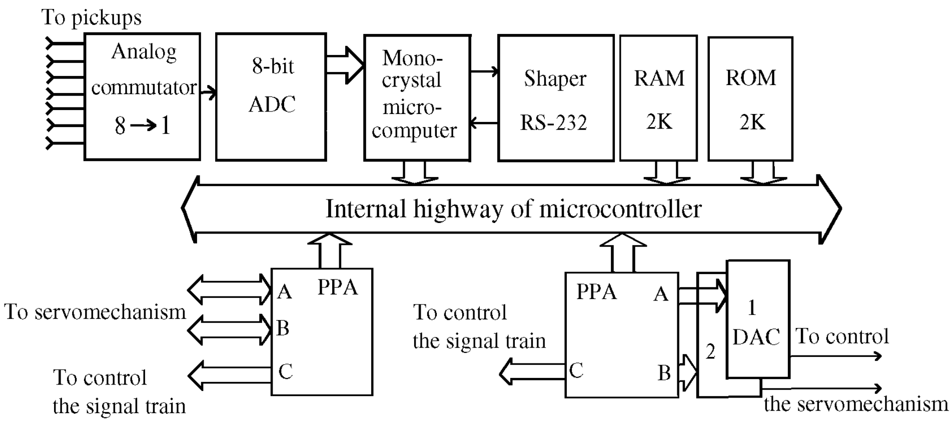

FIG. 3. Block diagram of the microcontroller of aerosol lidar.

The whole program which controls the microcontroller operation resides in the 573RF5 ROM. It consists of the invariable part referred to as program MONITOR and the control program which is specially elaborated for each lidar. The program MONITOR is intended for debugging of the control program and diagnostics of microcontroller and lidar units as well as for issue of the following nonstandard control instructions:

– to write byte in addressed memory,
– to read byte from addressed memory,
– to write byte in the RAM,
– to read byte from the RAM, and so on.

The operation algorithm of the control program depends to a large extent on the employed servomechanism. For the first time the microcontrollers were used in the LOZA–3 and LOZA–5 lidars equipped with radically different servomechanism, and in both cases the systems were not adapted.

The control program is intended for execution of two instructions: to scan in the given sector with fixed rate and to take a point with fixed rate avoiding the forbidden positions of the servomechanism in case of operator errors or instrumental failures. While these instructions are executed, microcontroller continuously yields the coordinates of the servomechanism and monitors the instructions coming from the operator through the communication line.

Microcontroller software was written in ASM51 and translated with the help of general–purpose cross system TASM operating in IBM PC under the control of MS–DOS.

REFERENCES

1. A.P. Rostov, Atmos. Oceanic Opt. **6**, No. 5, 356–358 (1993).
2. V.V. Stashin, A.V. Urusov, and O.F. Mologontseva, *Design of Digital Devices Based on Monocrystal Microcontrollers* (Energoatomizdat, Moscow, 1990), 224 pp.