THERMIK-2 UNIT FOR DATA RECORD AND INPUT FROM THERMOVISION SET INTO COMPUTER

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This paper presents an automated thermovision system with wide capabilities in recording both fast (recording rate up to 25 frames per second) and slow (recording rate down to one frame per 40 minutes) processes with the total number of recorded frames not less than 100. The wide potentialities for recording modes (recording rate, input frame size, frames summation option, etc.) setting and rather developed software are among the advantages of apparatus elaborated. The system is used for IR laser parameters investigation from the reflected or scattered radiation or from screen heating at pulse lasing.

The thermovision systems have found a wide applications in medicine, power engineering, metallurgy, military business, scientific researches, etc.[1–4] However, up–to–date thermovision systems lack automated data recording and processing units. In particular, it is characteristic for Russian thermovision sets. In practice a necessity often arises in measuring or investigating the temporal dynamics of thermal processes, for example, in measuring the temperature of rapidly heating or cooling objects, when recording information from aircrafts, at human body temperature change after some treatments or for giving a diagnosis, when measuring the laser beam parameters, etc. Each specific case requires specific spatiotemporal resolution of recorded information depending on rate of the process change and its spatial inhomogeneity.

The present paper describes the Thermik–2 unit for data record and input from thermovision set into computer, which has wide capabilities for studying the various thermal processes.

Thermik–2 is intended for data convert and record from thermovision set into buffer storage for following input and processing with a computer of IBM PC or DVK type. The key feature of the Thermik–2 is the fact that it is programmable device with various modes of recording, namely, 1) choice of a thermovision set type, 2) recording in real–time mode, 3) accumulation mode, 4) full frame or window mode, 5) frames skip mode, 6) lines or elements in line skip mode, 7) serial or arbitrary access to video memory of storage device (VSD) mode, 8) input videosignal extinction coefficient setting, 9) choice of ADC capacity (8 or 10 bit), and 10) choice of recording start up (program–initiated, manual, or from an external pulse).

The selection of recording modes extends the operational capabilities of thermovision set and the field of its application and provides the optimal use of buffer storage. The number of recorded frames depends on memory capacity and selected mode. For example, for 1 Mbyte memory, frame format 100×100 (100 elements in line and 100 lines in frame), and 8–digit ADC the number of recorded frames is 104 for mode of recording in real time, 416 for 50×50 window mode, and for accumulation mode or 10–digit conversion mode it is halved, since in doing so the storage device is used in mode of 16–digit words storage. The main advantages of Thermik–2 manifests themselves in studying the dynamics of thermal processes.

Let us consider the potentialities of above–enumerated modes in great detail.

1. The choice of thermovision set type. The clock rate of elements retrieval in line depending on its size is set up that allows the various types of thermovision sets to be used.

2. The recording in real time allows each frame to be recorded with the thermovision set operational rate. This mode is applied mainly in recording fast processes. It is used in combination with full frame or window mode and frames, lines, or elements skip modes.

3. Accumulation mode allows the summation of selected number of frames from 5 to 256 to be made and recorded in storage device as one frame and the selected number of frames between summarized ones to be skipped. It is used in combination with the rest recording modes. This mode is applied for better sensitivity in studying the stationary or slow thermal processes.

4. Window mode provides the optimal use of memory at the expense of recording only the information separated out by window within the frame. It is applied if the increasing in recording duration is wanted or in analyzing the frame part of interest.

5. Frames skip mode provides the recording with selected frame duty factor that allows the optimal recording mode to be chosen depending on process rate.

6. Lines or elements skip mode is applied if the longer time of recording (2 or 4 times longer in comparison with that of full frame or window mode) is needed for analyzing the process. It is applied mainly for recording long–term fast processes.

7. Serial access mode is applied in recording the information from thermovision sets. Arbitrary access mode allows the video storage device to be used as electronic disk.

8. Coefficient setting mode allows the coefficients to be added to the equation, which relates the amplitude of videosignal to temperature. This mode can be used in conjunction with a thermovision set and complete radiator as reference one to determine such coefficients.

Thermik–2 is an independent device with build–in power supply, conversion and control board (CCB), video

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storage device control board (VSDCB), and video storage device board (VSDB). The communication with computer is performed via computer interface. Such a design of Thermik–2 permits the various computers to be connected to it replacing only the interface board.

The exchange of information is performed via two programmed registers, namely, the instruction register (IR) and the data register (DR). Any program–available register and video storage device are chosen via IR, and the data exchange is performed via DR.

Block–diagram of Thermik–2 are presented in Fig. 1. CCB contains the storage and retrieval unit (SRU), analog–to–digital converter (ADC), as well as the program–available registers: instruction register (IR), reference rate register (RRR), skip permission register (SPR), states register (SR), frames, lines, and elements timers, each including the control word register, three channels of counters (0, 1, 2), and the program–driven attenuator.

Using RRR the period of reference rate may be set up within the range from 0.1 to 25.6 μs with 0.1 μs step that allows the required reference rate to be selected for operating with thermovision sets of different types and the retrieval rate in line to be changed, if necessary. SPR permits the passage of start pulses of frames, lines, and elements in image without skips. Counters 0 of timers are programmed via control word registers into the rate division mode to result the frames, lines, or elements skips. Counters 1 and 2 of lines and elements timers are programmed into flip–flop oscillator (C1) and strobe modes with hardware start–up (C2) and specify the coordinates of apparatus window start and its input format. Counters 1 and 2 of frames timer are programmed into strobe mode with hardware start–up (C1) and flip–flop oscillator mode (C2) and specify the number of summarized skipped frames in accumulation mode. SR specifies the configuration: memory chips type, conversion into 8– or 10–bit code, sinchronization type (line or frame–line), serial or arbitrary access to video storage device, permission or prohibition against ADC operation, and recording start–up type (hardware or software) as well as recording modes (full frame or window, recording in real time or accumulation mode) and indicates the recording start and video storage device overflow.

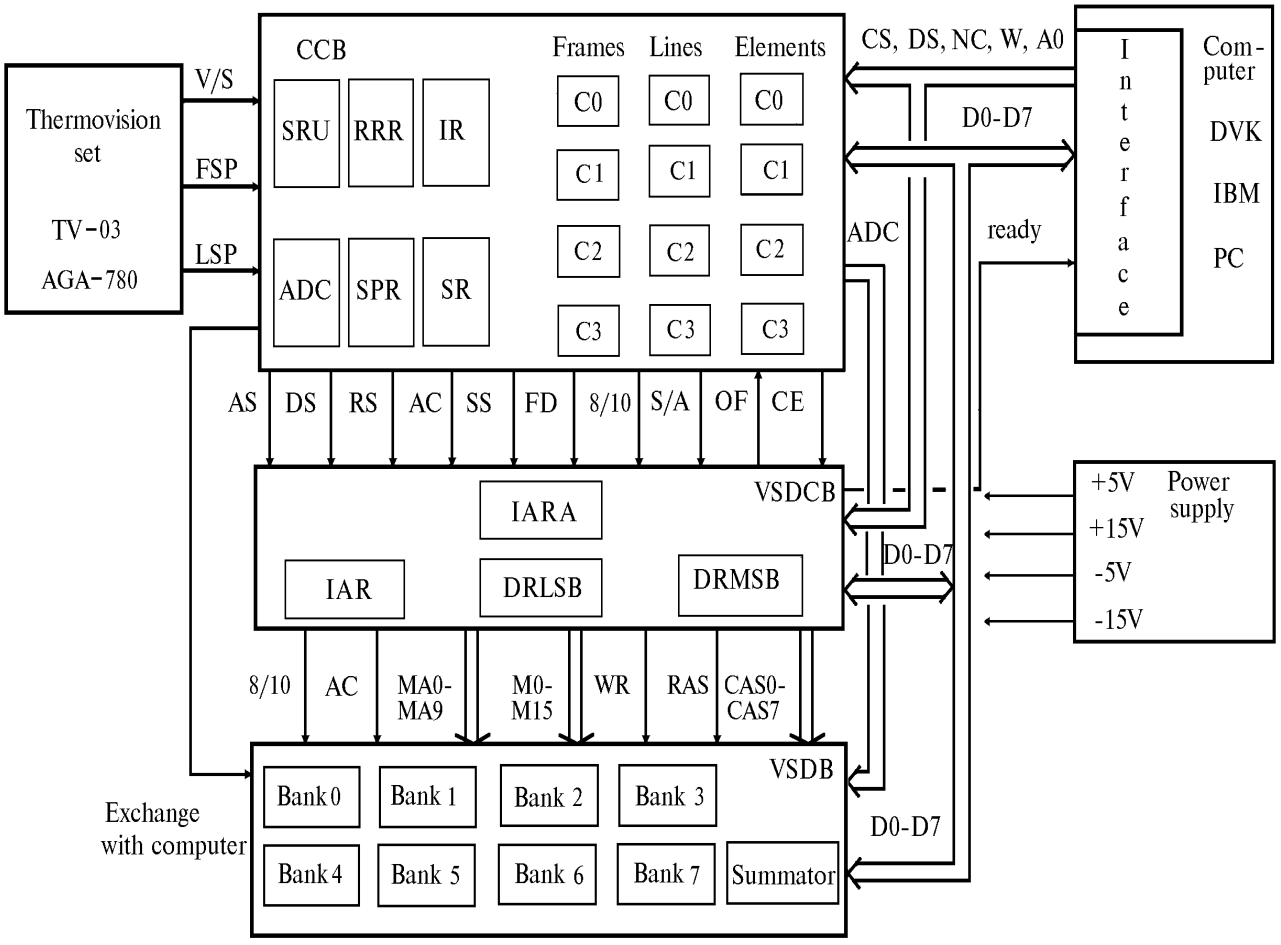

FIG. 1. Block–diagram of Thermik–2, where AS, DS, SS, and CS are the address, data, summation, and command strobes, RS is reset, AC is accumulation, FD is frame duration, 8/10 means ADC capacity, S/A means the access to video memory (serial or arbitrary), OF means overflow of video memory, CE means the ADC conversion end, MA0 – MA9 are address signals, M0 – M15 are readed data, WR is signal of writing, RAS and CAS0 – CAS7 are the pulses of address strobing, D0 – D7 are data buses, NC means the number of device choice, W means writing, A0 are the pulses of video storage least signification byte choice, VS denotes videosignal, FSP denotes frame synchropulse, and LSP denotes line synchropulse.

VSCB contains the program–available initial address register (IAR) and data registers of least significant and most significant bytes of video storage device (DRLSB and DRMSB, respectively), address counter (AC), initial address register at accumulation (IARA), address multiplexors and controller of VSB.

VSB contains 32 or 64 chips of dynamic memory of K565RU5, RU7 (4164, 41256) types and summator required for accumulation mode.

Before the start of recording the computer sets the registers in accordance with selected mode. SR is set after timer, SPR, and RRR being programmed and VSB initial address being inputted. The recording can be started up by either external hardware signal or "start" button or be program–initiated. Every time it starts from the frame start. In recording computer asks SR, then indicates the points in time corresponding to the recording start and VSB overflow (recording finish). After the completion of recording computer reads the frame or series of frames selected by operator from VSB and displays they on the monitor screen as color–coded picture. After viewing the picture an operator decides what frames to be processed or written on magnetic disk. Thermal image is written together with housekeeping information entered by operator as well as time and date.

Software is developed in TURBO PASCAL for IBM PC and in FORTRAN for DVK computer. It allows one to specify the system configuration and recording modes, to write thermal images into video storage or rewrite on disk, to read an information from video storage device or disk for viewing or processing, to view any selected frame of those recorded, to make the processing of selected frame, namely, to combine or subtract frames, to form the three–dimensional image, to separate out regions with the same temperatures, to determine temperature in a particular point and to draw the temperature distribution in sections through this point, to form the histogram of distribution, to transform thermal value to temperature, to read continuously series of frames in viewing simultaneously with read–out on display of up to eight frames, to make color or black–and–white gray–scale hard copy from display.

The program for statistic processing of selected groups of frames is developed, which consists in choosing a window in the frame part of interest and obtaining the following characteristics: obtaining, reading out on the display, and filing group–averaged frame and group–averaged frame when matching the centers of gravity, calculation and output of the coordinates and temperature values in maximum and center of gravity, rms dimensions of image for each frame (including averaged ones) as well as rms and average values of these characteristic averaged over the group, as a table. Application of this program allows the precision of determination of temperature distribution to be increased at the expense of program accumulation mode and the process change in time to be obtained.

Thermik–2 was tested with thermovision sets Electronika TV–03 (Russia) and AGA–780 (Sweden). Specifications of Thermik–2 presented in Table I.

TABLE I. Thermik–2 specifications

ADC capacity, bit	8 or 10
ADC conversion time, μs	0.75 or 1
Video memory, kbyte	256, 512, 1024, 2048
Number of skipped frames in recording in real time	1–65536
Number of summarized frames in accumulation mode	5–256
Number of skipped frames between summarized ones	1–256
Recording of full frame or part of it (window)	
Rate of reference oscillator, μs	0.1 –25.6
Videosignal extinction coefficient	1:1, 1:2, 1:4, 1:9
Maximum frame size at frame rate of 16 Hz	not greater than 256×256

Interface provides the operation of two units in parallel for one computer.

There is no analogs to Thermik–2 except up–to–date thermovision system BRUT (AGEMA, Sweden), which has larger memory but is more expensive.

The main advantages of Thermik–2 are the following capabilities:

– to connect the thermovision sets of various types with various computers;

– to record in dependence on thermal process change rate and to use of buffer memory at an optimum;

– to use the software package for thermal images processing and to expand it in future.

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