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Semenov A. O., Doctor of Technical Sciences,
Professor at the Department of Information Radioelectronic Technologies and Systems
Vinnytsia National Technical University
ORCID: 0000-0001-9580-6602

Stalchenko O. V., Candidat of Technical Sciences,
Associate Professor at the Department of Infocommunication Systems and Technologies
Vinnytsia National Technical University
ORCID: 0000-0003-4764-1502

Voitsekhovska O. O., Ph.D.,
Assistant at the Department of System Analysis and Information Technologies
Vinnytsia National Technical University
ORCID: 0000-0001-8504-1204

Khloba A. A., Master Student at the Department of Information Radioelectronic Technologies and Systems
Vinnytsia National Technical University
ORCID: 0009-0007-6743-2456

Krystoforov A. V., Postgraduate Student at the Department of Information Radioelectronic Technologies and Systems
Vinnytsia National Technical University
ORCID: 0000-0003-0616-667X

SYNTHESIS OF A DEVICE FOR REMOTE CONTROL OF A VIDEO CAMERA USING THE LANC PROTOCOL

The expediency of using video camera remote control devices when using auxiliary video equipment is proven by the ever-increasing level of complexity and improvement of modern video shooting technologies. Companies producing systems for remote control of video equipment offer control systems with wireless radio interfaces for high-budget projects. But the price of such an interface can exceed the cost of a high-budget professional video camera. In most cases, management interfaces differ from manufacturer to manufacturer and are implemented based on leading wired management protocols. The use of these protocols is largely due to the need to implement very high-speed information transmission and its strict synchronization with the frame pulse generator of the video camera, which in turn provides control of entire groups of objects with high speed and fairly accurate synchronization in time, as well as wired information transmission lines are more secure and reliable. The object of research in the work is the widespread LANC protocol (CONTROL-L), which is used by two-way data exchange systems and is necessary for the remote control of video cameras. The paper proposes a device based on this protocol that allows remote control of the camera (data exchange takes place via cable). For this, an overview of existing video camera control devices was conducted. The analysis of the LANC protocol was carried out, and its working principle was considered. The protocol allows you to use 14 steps of changing the zoom speed (7 speeds in the direction of increasing the image and 7 speeds in the direction of reducing the image), so for an almost smooth gradual increase or decrease in the speed of the zoom; it is advisable to use not discrete buttons, but an analog variable resistor-joystick. The proposed electric circuit of the *video camera remote control device is based on the Microchip microcontroller – PIC16F84. Modern microcontrollers have low consumption currents, so it becomes possible to use the power supply line of external devices built into the LANC connector to power the remote control controller, which allows you to connect a load with a current of up to 100 mA. The operation of the device was checked during the simulation. The correct operation of the algorithm for converting the resistance of the "joystick" resistor of the zoom into the command code has been confirmed. The given oscillograms are obtained from the device layout. The obtained results confirm the protocol's theory and the device's correct functioning.*

Key words: *LANC protocol, CONTROL-L protocol, video camera, remote control, auxiliary video equipment.*

Семенов А. О., Стальченко О. В., Войцеховська О. О., Хльоба А. А., Кристофоров А. В. Синтез пристрою дистанційного керування відеокамерою з протоколом LANC

Доцільність використання пристроїв дистанційного керування відеокамерами при застосуванні допоміжного відеообладнання доведена постійно зростаючим рівнем складності та поліпшенням сучасних технологій відео зйомки. Фірми-виробники систем дистанційного керування відеообладнанням пропонують для високобюджетних проектів системи керування з бездротовими радіоінтерфейсами. Але такий інтерфейс по ціні може перевищувати вартість високобюджетної професійної відеокамери. В більшості випадків інтерфейси керування відрізняються у різних фірм-виробників та реалізуються на основі провідних протоколів керування з дротовим зв'язком. Використання цих протоколів більшою мірою обумовлено необхідністю реалізації дуже високої швидкодії передачі інформації та її жорсткої синхронізації з генератором кадрових імпульсів відеокамери, що в свою чергу, забезпечує керування цілими групами об'єктів з високою швидкодією та досить точною синхронізацією у часі, також дротові лінії передавання інформації є більш завадозахищеними та надійними. Об'єктом дослідження у роботі є розповсюджений протокол LANC (CONTROL-L), який використовується системами двостороннього обміну даними і необхідний для дистанційного керування відеокамерами. В роботі запропоновано пристрій якій ґрунтується на даному протоколі і дозволяє керувати камерою на відстані (обмін даними відбувається по кабелю). Для цього було проведено огляд існуючих пристроїв керування відеокамерами. Проведено аналіз протоколу LANC, розглянутий його принцип роботи. Протокол дозволяє використовувати 14 кроків зміни швидкості трансфокатора (7 швидкостей в сторону збільшення зображення та 7 швидкостей в сторону зменшення зображення), тому для майже плавного поступового збільшення чи зменшення швидкості трансфокатора доцільно використовувати не дискретні кнопки, а аналоговий змінний резистор-"джойстик". Запропонована електрична схема пристрою дистанційного керування відеокамерою на базі мікроконтролера фірми Microchip – PIC16F84. Сучасні мікроконтролери мають малі струми споживання, тому стає можливим використати для живлення контролера дистанційного керування, вбудовану в роз'їм LANC лінію живлення зовнішніх пристроїв, яка дозволяє під'єднати навантаження зі струмом до 100 мА. Роботу пристрою перевірено при моделюванні. Підтверджено правильність роботи алгоритма перетворення опору резистора "джойстика" трансфокатора в код команди. Наведені осцилограми отримані з макету пристрою. Отримані результати підтверджують теорію роботи протоколу і коректність функціонування пристрою.

Ключові слова: *протокол LANC, протокол CONTROL-L, відеокамера, дистанційне керування, допоміжне відеообладнання.*

Formulation of the problem. Modern video production is characterized by a high level of competition. Special small operator cranes, carts, and Steadycam systems have become an important part of the range of tools used by modern teleoperators of medium and small television studios. Also, in reportage shooting, such auxiliary camera equipment as all kinds of tripods, poles, monopods, etc., are widely used [1]. It becomes obvious that when using larger auxiliary camera equipment, the contact of the videographer with the control bodies of the video camera becomes difficult or, in many cases, completely impossible.

In order to solve the problems of remote interactive information exchange and control commands between a person and video recording equipment, video equipment manufacturers have developed appropriate information interfaces. These control interfaces can not only accept commands from the videographer but also transmit data back from the video device to the person. These data, as a rule, contain a lot of useful information, namely information about the state of the video camera (turning on, recording, etc.), the time code of the recording, the state of the controllers and their setting parameters, self-diagnostic signals (state of the batteries, contamination of the LPM, etc. .p.) and much more.

The initial price range of professional video recording equipment includes three leading manufacturers of video cameras, which are in particular demand in Ukraine and many countries worldwide – Panasonic, Sony, and Canon. Manufacturers Sony and Canon use a unified three-wire interface called CONTROL-L, also known as LANC, for the remote control of their camcorders.

Therefore, developing and researching a device for remote control of video cameras that uses this widespread interface is an urgent technical task, the solution of which is given in this article.

Analysis of recent research and publications. Systems and means of remote control of stationary and television video cameras are actively being developed and improved; they are gradually moving away from the leading means of control and beginning using Bluetooth and WiFi, infrared remote controls, and control using web services [2]. Camera control systems using vision are being developed [3] for remote observation of meteors [4]. Today, a large number of companies are engaged in the production of various tools for remote camera control [5]. They are mainly divided into those that work using the LANC protocol, CCU remotes, and PTZ cameras [6].

The interface for remote control and synchronization of video equipment LANC is currently the most widespread interface of this type because it is supported by the two most massive manufacturers of quality equipment, these are Sony and Canon, whose video equipment is very widespread and popular in most countries of the world. Secondly, it allows you to implement almost all functions necessary for portable remote control and data exchange with video equipment at a professional level. Developments based on it are successfully implemented [7].

LANC controllers of different manufacturing companies with different technical and operational characteristics, different design complexity, and a fairly large fluctuation in the price range – from a few tens of dollars to a thousand or more. Even quite simple controllers with a set of the most necessary functions do not fall below $100 in price. Given the openness of the protocol, there is an opportunity to develop a fairly functional low-cost LANC video camera remote control device with a small price.

The purpose of the article: synthesis of a device for remote control of a video camera that uses the protocol LANC on a widespread elemental base with simple management. To achieve the goal, the following tasks must be solved: 1) understand the features of the LANC protocol; 2) take into account the peculiarities of the protocol and synthesize a schematic diagram; 3) get the results of the protocol from the designed device.

Presenting main material. The LANC (Local Application Control Bus System) protocol is used to create systems of wired two-way data exchange between the remote control object and the controller.

Controllers for video camera remote control systems using the LANC protocol are usually designed and manufactured based on serial or specially developed microcontrollers [8]. These microcontrollers scan the position of the controls and accordingly form, according to the LANC protocol specification, a serial code containing commands to control the functions of the video camera. The generated code is rigidly synchronized from the generator of frame sync pulses; that is, the remote controller is constantly in “slave” mode to the device it controls. The controlled device constantly “interrogates” the control panel with the frequency of frame pulses. This is the main difference in the operation of this protocol and makes it possible to organize the two-way exchange of information over one wire in synchronous mode [8].

The LANC remote control device is connected to the video camera itself using a flexible three-wire (for the option of powering the remote controller from the video camera) or two-wire (for the option of powering the remote controller from an independent voltage source) cable, at the end of which there is a plug of the “mini” standard -jack” with a diameter of 2.5 mm.

LANC serial bidirectional communication protocol for communication between two devices. Data exchange is organized according to a one-wire circuit with an open collector. An example of controlling such a bus is shown in Figure 1 [9].

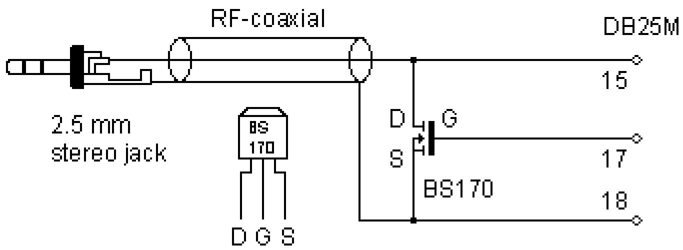


Fig. 1. An example of an open-collector circuit for controlling a LANC data link [9]

A camcorder or stationary video camera to which a remote control device is connected can receive commands and send back information about the status of the device.

The camcorder provides a large amount of feedback: time code, data codes, counter code, remaining time code, warning signal codes, and control feedback codes.

The essence of the protocol construction is that the “master device” (camcorder or stationary video camera) generates a message frame by creating 8 start bits, each of which is followed by 8 information bits (1 byte) and a long stop bit. After that, everything starts over [10]. The general appearance of a LANC protocol message is shown in Figure 2. The duration of one bit is 104 μs. The distance between two start bits can vary from 1200 μs to 1400 μs depending on the model and type of video camera.

The distance between two information messages is 20 ms for the PAL/625 television system and 16.6 ms for the NTSC/525 television system. These time intervals are consistent with the time intervals of the RS232 data transfer protocol with a speed of 9600 Baud [11].

Due to the fact that the LANC data bus is built according to the open-collector circuit, the normal state of the bus is a high logic level (5 V), and when a data bit is transmitted, this bus is "pulled" to "ground". As mentioned above, this bus is compatible with the RS232 protocol according to the timing diagrams, but if it is necessary to connect the video camera to a personal computer directly, the signal must be inverted before it is used (otherwise, the byte with the value 00 will be perceived as FF).

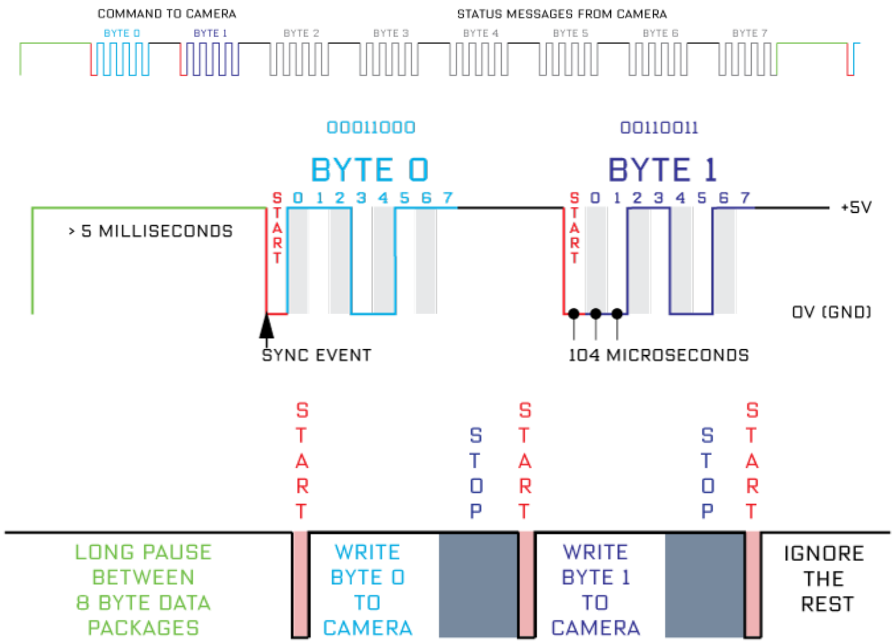


Fig. 2. General view of the timing diagram of the LANC protocol message [11]

The formation of the protocol is carried out as follows. With each frame pulse of the internal synchro generator, the video camera forms eight consecutive byte data packets on the corresponding contact of the LANC connector. The purpose of these bytes is as follows: the first two are intended for the video camera command manager (controller); the next two to control the tuner; the last four – for transmitting information about the status of the video camera or VCR, counter data, time code and some other service bits. That is, the first four bytes are used to transmit information from the control controller to the video camera, and the last four are for feedback (transmission of data from the video camera to the control controller).

In order to send a command from the controller to the video camera, it is necessary to wait until the start bit of the first byte in the message frame appears on the line [12]. After that, it is necessary (observing all necessary time intervals) to add your necessary signal within this byte to the LANC line (we are dealing with an open collector and an inverted signal – "pull-up" only to "0" to form the command bit).

The serial data line has a normal high state (+5 V), and the start bit has an active low state (0 V). Data bits are transmitted inverted, i.e., "1" -> 0 V; "0" -> 5 V. The stop bit has a high (+5 V) state. The video camera sends a set of 8 bytes once, synchronously, with each field of the video signal (50 times per second for the PAL system). Apart from the start and stop bits, no other information is transferred between the 8-byte packets, but there is a large time gap between each 8-byte packet. In order to know exactly with which byte the packet begins, it is necessary to observe the duration of this long time interval for its detection.

When forming a data packet from 8 bytes, the video camera does not fill the first four bytes with information, always leaving them free (leaves the line open for the +5V control device) and instead simultaneously reads data from the first four bytes on its side. Generating, shaping, and filling the first four bytes is the task of the remote control device. When forming the next and last four bytes, the video camera fills them with bits intended for sending to the control device. Therefore, the task of the remote control device is to switch to the information-receiving mode after sending the fourth byte, although this is not mandatory and depends on the functional features of the remote control device [12].

The remote control device (controller) that wants to send a command to the video device must wait for the start bit of the first byte from it and then start the transmission mechanism of the correct 8-bit data code, which is synchronized with the video device at the required transmission rate.

The interference protection system of the LANC protocol requires from the control device that the command code transmitted to the video device is duplicated in at least four fields in a row. Otherwise, the command will not be received and executed by the command decoder [13].

The length of the connecting cable (from the camcorder to the remote control device) can easily be exceeded 10 m, and when using additional intermediate repeater amplifiers (repeaters), it may exceed distances of 100 m and more.

Taking into account the above functionality of the remote control device, the following functions will be implemented:

1. Entering control commands from the keyboard (zoom – 14 commands, record, backlight) a total of 16 commands;

2. Entering zoom control commands using a resistor-joystick (smooth change of zoom speed) 7 speeds for zooming in and 7 speeds for zooming out;

3. Formation and transmission of control commands to the video camera according to the LANC protocol, reception of the "recording" mode status command from the video camera;

4. Display the "recording" mode on the LED indicator power supply on the LED indicator.

The command generation and transmission functions can be easily changed by replacing the command code constants in the program [14]. That is, if some command is unnecessary, it can be easily replaced with the necessary one.

This command formation principle is very flexible and can be applied when adapting the remote control device to different video camera models because not all LANC video cameras use the same control command codes.

A keyboard with non-locking buttons (matrix 4x4) and a joystick-type command input device based on a variable resistor with a normal middle position of the slider will be used as controls.

A special need often arises in using different zoom speeds and their smooth change. The commands that will be generated by the "joystick" (instead of discrete buttons) of the zoom in the microcontroller program will also be duplicated on the keyboard in case it is necessary to get direct access to the fixed speed of the zoom. The status of the "recording" mode will be displayed in the indicator block, the code of which will be received from the video camera via the return channel of the LANC line. The basic electrical diagram of the device is shown in Figure 3.

A microcontroller manufactured by Microchip Technology PIC16F84-04 will be used to build the device. This microcomputer has 1 kb of program memory, 36 bytes of RAM (which is quite enough), quite high speed, two input/output ports (one for the keyboard matrix 4x4, and the second port for connecting the LANC line, measuring the resistance of the variable resistor "joystick" of the zoom and connecting the "recording" indicator) [15]. Low power consumption will allow the device to be powered directly from the video camera through the LANC connector without using an external or built-in power source [16].

Microcontrollers of this series have a built-in reset circuit on a timer with a fixed time interval for turning on the clock generator. This time is approximately 70 μs. But with a slower rise of the supply voltage, it is recommended to use an external delay circuit, and the resistor R2 is connected to the microcontroller's supply circuit with the left terminal. In addition, a forced manual reset of the processor will be introduced in case of a non-stationary situation. The reset will be carried out by closing the button SA1, installed in parallel with the capacitor C3. To limit the current at input 4, the manufacturer of this microcontroller recommends installing a 100-300 Ohm resistor in series with the input.

The clock generator will be made according to an external circuit with quartz frequency stabilization. This is necessary for strict binding to the time intervals of the LANC protocol formation algorithm.

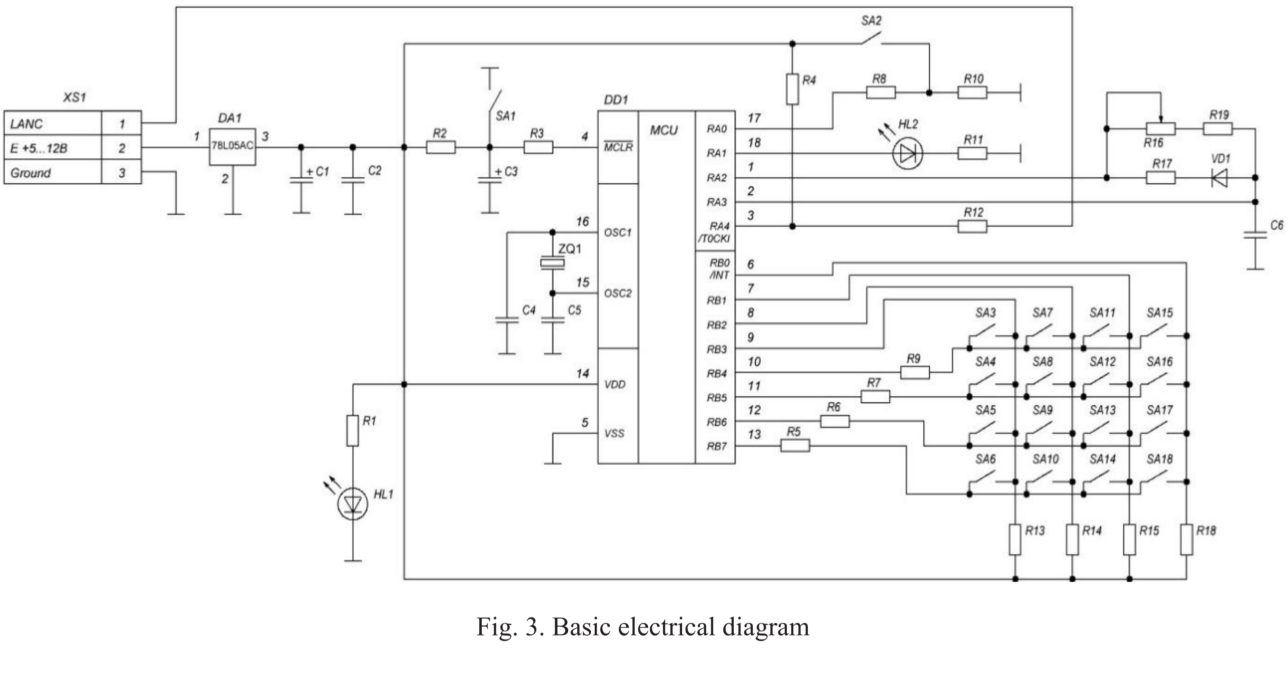


Fig. 3. Basic electrical diagram

We choose a quartz resonator at a frequency of 4 MHz, and all procedures for forming time intervals in the microcontroller firmware program will be tied to this frequency. Additional capacities C4 and C5, necessary for the stable start-up of the generator, are recommended by the manufacturer [17].

Port B of the microcontroller is used to scan the keyboard. The four lower bits of the port (RB0-RB3) are used as inputs, and the four higher bits (RB4-RB7) are alternately supplied with a low logic level.

To set high levels at inputs RB0-RB3 in the mode where the button is not pressed, "pull-up" resistors R13-R15 and R18 are used, which are connected to the +5V power supply line. The ratings of these resistances are chosen in the range of hundreds of kilohms based on considerations of high resistance in the input mode (for field-effect transistors, this is megohms) and the limitation of the maximum current through the output lines (RB4-RB7). We choose the standard values of these resistors of 100 kΩ.

Resistors R5-R7 and R9 protect Port B outputs RB4-RB7 from simultaneous button presses and reduce the current flowing through the pressed buttons and port outputs to a safe level. We choose 10 kΩ.

To connect the "record" indicator, the output of RA1 port A is used and configured to output. The load capacity of the microcontroller ports of this series allows you to disconnect LED indicator devices without using additional drivers.

The principle of operation of the variable resistor "joystick" zoom control circuit is based on the principle of measuring the constant time of the charging circuit of the capacitors R16, R19, and C6. The charge time of the capacitor C6 is directly proportional to the position of the knob of the variable resistor R16. The input of the circuit is connected to the output of port A – RA2, configured as an output, and the output of the circuit is connected to the output of port A – RA3, configured as an input. Initially, capacitor C6 is discharged. In the measurement cycle, a high level is applied to the RA2 output, and the time is calculated, after which the voltage on the capacitor C6 reaches the level of logical "1". This time will be proportional to the resistance of resistors R16, R19. After the voltage on C6 reaches level "1" (approximately 1.3 V), the value of the measured time is stored in the corresponding register of the microcontroller, after which the high level at the output of RA2 changes to low and the capacitor is quickly discharged through the circuit R17, VD1. The discharge time constant of capacitor C6 is chosen much less than the average charge time, so the capacitor has time to fully discharge before the next measurement cycle.

Let's take the resistance of the variable resistor "joystick" of zoom control R16-10kΩ. We set the maximum voltage on capacitor C6, which will be perceived by the input of port A as the level of logic "1" – 1.3 V. The resistance of resistor R19 is based on the condition of the maximum permissible current through the output of the port, and the minimum resistance of variable resistor R16 (about 0 Ohm) is equal to 200 Ohm. Taking into account that the capacitor C6 will be completely discharged at the beginning of the measurement cycle, the current value at this time will be maximum.

The LANC line is an open-collector line, so a "pull-up" resistor must be used to produce a normal operating voltage level in the line. Output is arranged through port line A RA4. Depending on the performed actions, this line works for input or output. The "pull-up" resistor to the logic level "1" – R4 is chosen to be about 10 kΩ. The resistance of resistor R12 is calculated from the condition of protection of the output of port A of the microcontroller against short circuits in transmission modes [18].

The program consists of three main modules:

1. The main part, the function of which is the synchronization and formation of the data exchange protocol over the LANC line, reading the bytes of the video camera status and transmitting the control commands of the video camera;

2. Subroutine for scanning the keyboard matrix, forming or preventing the repetition of command transmission, the anti-chatter function of the keyboard buttons, measuring the resistance of the zoom "joystick" resistor;

3. The subroutine of the command decoder, the task of which includes processing the received code of the pressed button, assigning it a command code, and forwarding this command to the formation and transmission module using the LANC protocol.

For computer modeling, let's choose a part of the program that is responsible for measuring the resistance of the variable resistor "joystick" of the zoom and turns it into a four-bit code [19]. The resulting code is fed into the four lower bits of port B.

The resistance measurement routines work as follows. A high level is applied to the output of port A, bit 2, to which the input of the measuring RC circuit is connected. The charging of the capacitor C1 through the resistor R1 begins. After that, the measurement time constant is recorded in the counter. The value of the constant is then decremented by one and checked to see if the constant has reached zero. If the time constant is exhausted, the measurement ends, then the current value of the time counter is stored and output to port B. If the time constant is not equal to zero, the value of bit 3 of port A (capacitor voltage) is read. If the voltage on the capacitor has not reached a high logic level, the time counter is once again reduced by one unit, and the measurement cycle is repeated.

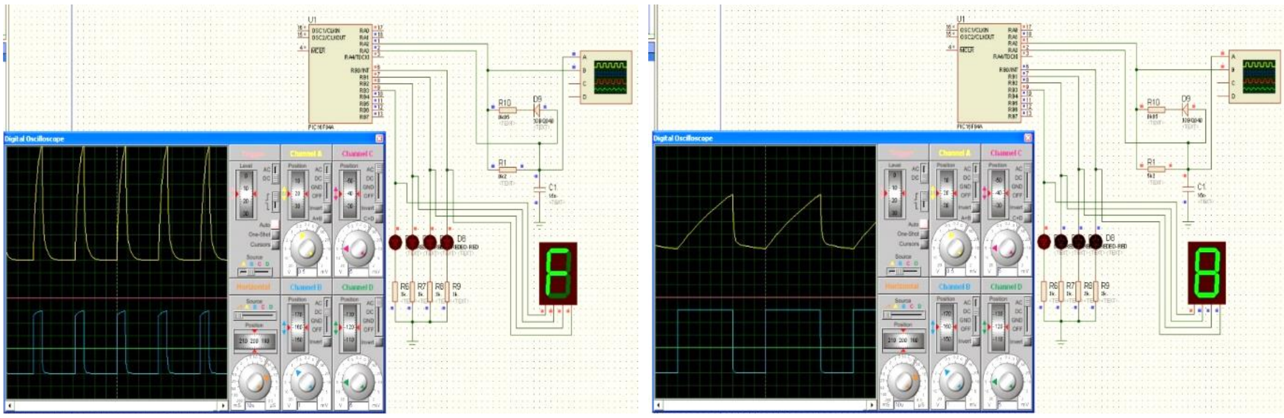
Modeling is carried out in the Proteus 7.2 program. We will connect a measuring RC circuit to port A, a virtually programmed microcontroller, and a digital indicator of a four-bit code to port B. We also connect a two-channel oscilloscope to the measuring RC circuit, channel A to the output of the circuit (in parallel with capacitor C1 – input 3 of port A), and channel B to the input of the circuit (input 2 of port A).

Resistor R1 simulates the variable resistor “joystick” of the zoom; the simulation will be carried out at two of its values: the minimum resistance value, average resistance value, the maximum resistance value.

The results of measurements at the minimum resistance value of the resistor R1 are shown in Figure 4, a. We see that at the minimum resistance value of the resistor (0.2kΩ), the number of commands transmitted to the decoder is equal to 0Fh. This value in the command decoder corresponds to the zoom zoom maximum approach speed command. We see that at the average value of the resistance of the resistor (5.2 kΩ), the number transmitted to the command decoder is equal to 08h (Figure 4, b). This value in the command decoder corresponds to the absence of any action.

Computer modeling confirms the correct operation of the algorithm for converting the resistance of the “joystick” zoom resistor into the command code. In the middle position of the joystick, a code of no action (08h) is generated.

As the “joystick” handle is deflected in the direction of decreasing resistance, codes from 09h to 0Fh will be formed in turn, which will be interpreted by the decoder as an increase in the speed of the zoom zoom. When the “joystick” knob is moved in the direction of increasing resistance, codes from 07h to 00h will be formed in turn, which will be interpreted by the decoder as an increase in the speed of the zoom zoom.



(a) (b)

Fig. 4. Simulation at: the minimum value of the resistance of the resistor R1 (a), the average value of the resistance of the resistor R1 (b)

On the device layout, oscillograms were obtained (Figure 5), confirming the above theory regarding the operation of the LANC protocol and the correct operation of the device.

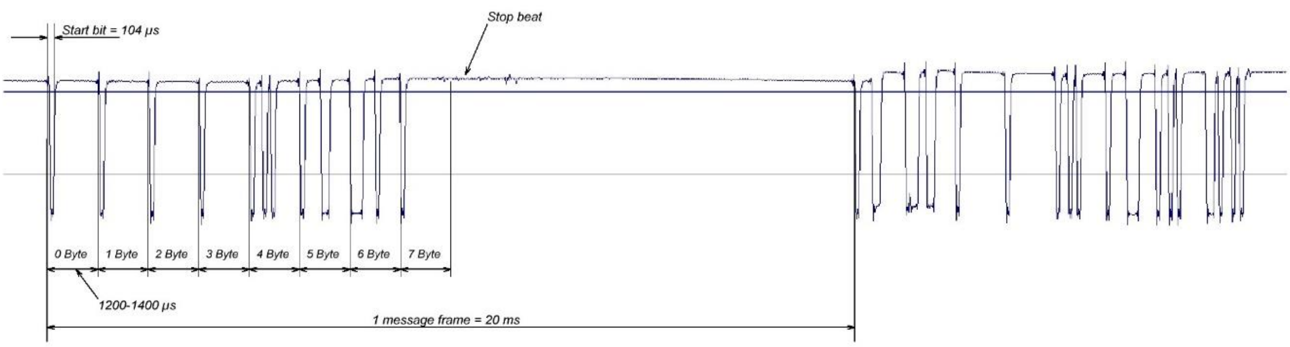
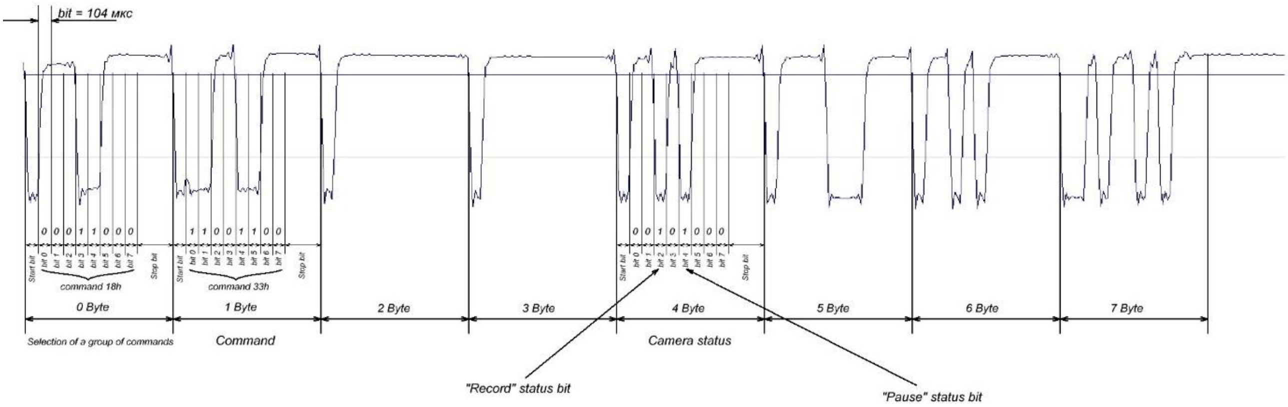
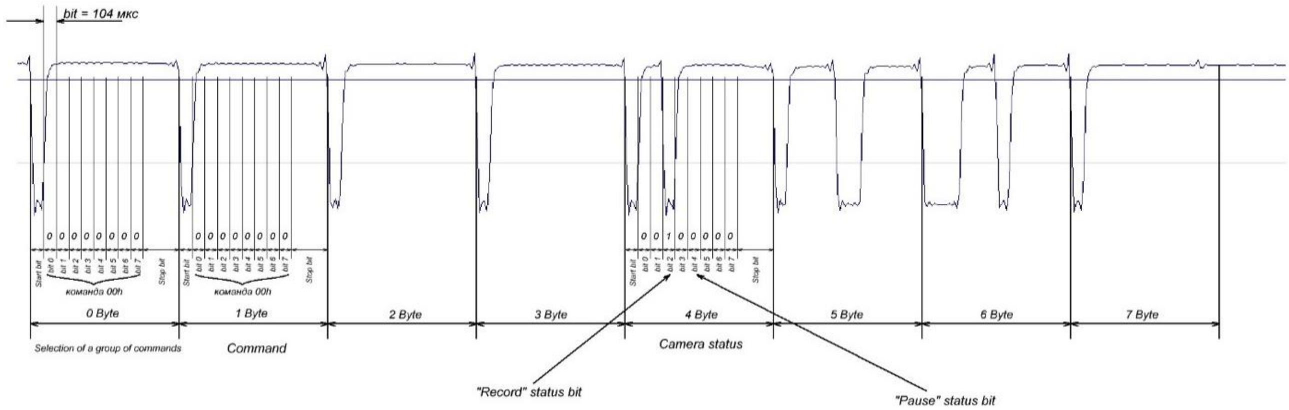


Fig. 5. General view of the timing diagram of the LANC protocol

Figure 5 clearly shows 8 bytes of information, start and stop bits, pulse duration, and total transmission time. In Figure 6, a timing diagram of one message frame is shown when the “Start Recording” command is transmitted (the command is only transmitted), and the distinction between the selection of a group of commands, the command itself, and the status byte from the camera is visible. Figure 6b shows the timing diagram of one frame of the message after sending the “Start Recording” command (the command has already been sent, and a response from the camera has been received).



(a)



(b)

Fig. 6. Oscillogram of transmission of the “Start Recording” command (a), after transmission of the “Start Recording” command (b)

Conclusions from this study and prospects for further research in this direction. A video camera remote control device was synthesized based on the LANC protocol. Control commands are entered using a keyboard or “joystick”. The operation of the device was checked by simulation and on the model. The further development of research in this direction consists of the transition to radio frequency options for controlling the camera, which will expand the distance and the number of possible locations.

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