Infrared Transceiver for Home Automation

Ivana Šenk, Laslo Tarjan, Gordana Ostojić, and Stevan Stankovski

***Abstract*—In home automation there is often a need for control of devices that have a built-in receiver for infrared communication with a remote controller. When trying to integrate such devices in a single control system, it is possible to substitute the remote controller with another infrared transmitter which automatically controls the device. This paper suggests a solution with an infrared transceiver which is connected to a computer via the USB interface. The receiving part records commands from the remote controller, while the transmitting part takes the role of the remote controller, and provides direct device control from the computer, or indirect control through the computer network. This system provides efficient and simple control of the home devices in the absence of the user.**

***Index Terms*—About Infrared communication, remote control, home automation.**

I. Introduction

HOME automation (the following terms are also used: house control, domotics, smart home, intelligent home) is a set of devices, systems or subsystems in a residential environment that are linked in a unique system, which enables automatic control of individual devices or systems [1].

The reasons for implementing home automation are various, it can increase security of a house, provide energy savings, provide centralized device control, provide device control in the absence of the user, etc. Development of home automation was mainly initiated by the need for security, so various alarm systems were developed, which ensure house supervision, and in case of any security risk, they activate the alarms, call telephone numbers, etc. For security purposes various other systems were developed, such as systems that simulate the presence of users. In such systems, in the user absence, the blinds are raised or lowered, and lights, audio and video equipment are turned on or off at specified time.

Today, home automation includes various systems [2], such as control of lighting, air conditioning or blinds, security systems, control of audio or video devices, automated flower watering or pet feeding, etc. Also, various access control systems are included in home automation, such as automated control of a garage door or unlocking the entrance door automatically, e.g. with the use of RFID technology [3]. All of these systems can be connected either by wires or wirelessly.

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As a large number of home devices have a built-in possibility of remote control, it is convenient to use this possibility when introducing an automated control system.

Most devices have a built-in infrared receiver for remote control, which enables easy integration of such devices in a home automation system, without the need for additional network installation. In this paper a solution is proposed, which substitutes a remote controller with an infrared transmitter that connects to the USB port of the computer and enables automated device control from the computer, or indirect control through the computer network.

II. Infrared Communication for Remote Control of Devices

Infrared communication [4] is a wireless communication which requires optical visibility, i.e. the transmitter and the receiver must be in direct line of sight, and no objects can stand between them. This type of communication is used for connecting devices in short range, usually in a same room.

Producers of home devices have developed and use different protocols for infrared communication and remote control [5]. All of these protocols for remote control use digitally modulated signal. The carrier frequency of the signal can vary, but in 90% of the cases the frequency of 38 kHz is being used [6].

For control of audio and video devices, most widely used are the Philips RC-5 (in Europe and USA) and NEC protocol (in Japan).

Philips RC-5 protocol [5] defines the carrier frequency of 36 kHz, constant bit length of 1.778 ms and message length of 14 bits. For signal encoding, bi-phase modulation (Manchester code) is being used (Figure 1), where each bit is represented by a certain state switch. Logical „one“ is represented by a switch from low to high signal state, and a logical „zero“ is represented by a switch from high to low signal state. High signal state is represented by the existence of the carrier frequency signal, while the low signal state is represented by its absence.

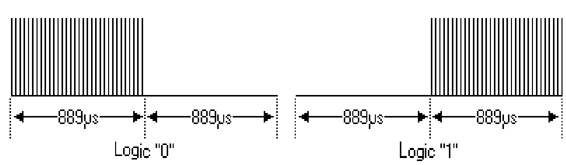

Fig. 1. Bi-phase modulation (Manchester code) – a logical „zero“, and logical „one“.

According to this protocol, a message (Figure 2) starts with two start bits with logical „one“ value. The third bit is a

„toggle" bit, which is inverted every time when a key of the remote controller is released and pressed again. The following five bits represent the device address, and the last six bits represent the command itself.

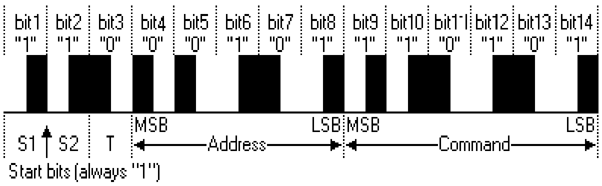

Fig. 2. Philips RC-5 protocol – message.

If the key of the remote controller is still pressed, the whole message is sent again after 114 ms. In this case, the „toggle" bit stays at the same logical level, so the receiver can understand that it is the same message, and not double activation of the same key.

NEC protocol [5] defines the carrier frequency of 38 kHz, bit length of 1.125 ms (logical „zero") or 2.25 ms (logical „one"). For signal encoding, pulse distance encoding is used (Figure 3), where each bit is represented with high signal state for 562.5 µs, followed by low signal state for 562.5 µs for a logical „zero" or 1.6875 ms for a logical „one".

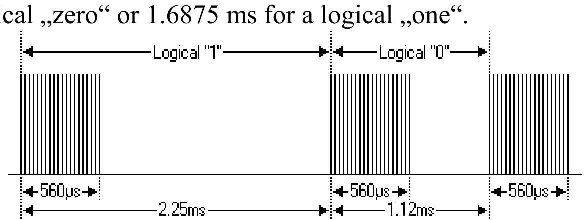

Fig. 3. Pulse distance encoding – a logical „zero", and logical „one".

According to this protocol, a message (Figure 4) starts with a pulse that lasts 9 ms, followed by a pause of 4.5 ms. The following 8 bits represent the device address, and they are followed by 8 bits representing the inverted device address, that can be used for verification of data. After that, the following 8 bits represent the command itself, again followed by 8 bits representing the inverted command, for verification of data. At the end of the message is a pulse 562.5 µs long. The time for sending one message is constant, as every bit is sent twice – noninverted and inverted.

Fig. 4. NEC protocol – message.

The message is sent only once, even if the key of the remote controller is kept pressed. In that case (Figure 5) the message is followed by a code that consists of a pulse of 9 ms, pause of 2.25 ms and a pulse of 562.5 µs, which is repeated every 110 ms.

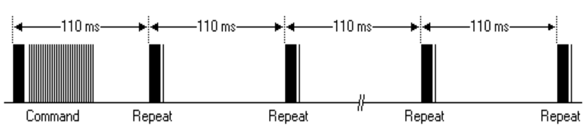

Fig. 5. A message followed by a code that is repeated every 110 ms.

III. Realization of an Infrared Transceiver for Home Automation

In this paper, a solution for an infrared transceiver is presented, which connects to the computer through the USB interface, and enables integration of various devices that can be controlled by infrared signals in a complete system of home automation. A transceiver has been realized, and its final layout can be seen in Figure 6. The transceiver consists of two functional units – a transmitter and a receiver of infrared signals.

Fig. 6. Infrared transceiver.

The receiving unit detects infrared signals from the remote controller, and enables control of the computer with the remote controller or recording commands from the remote controller for further control of the devices. For registering infrared signals an integrated chip SFH 5110-38 is used. This integrated chip consists of a photodiode, preamplifier, automatic gain control, bandpass and demodulator, and is in a housing designed as daylight-cutoff filter. The integrated chip SFH 5110 exists in several versions, depending on the signal carrier frequency, and can detect signals of carrier frequency between 30 and 40 kHz. For realization of the receiving unit the chip that detects signals of carrier frequency of 38 kHz is chosen, as it is the most frequently used carrier frequency in remote controllers. Output from this chip is the signal itself, without the carrier frequency, and this signal is led to the microcontroller pin.

The transmitting unit is used for sending infrared signals and automatic control of devices instead of the remote controller. The signal is generated from the microcontroller, and sent via an infrared LED.

Central part of the infrared transceiver is the microcontroller Atmel AVR ATmega8, which integrates the receiving and transmitting unit, and connects them with the computer through the USB interface. Connection with the computer is established through the integrated chip FT232RL, which converts USB communication to RS232 serial communication, which is supported by the microcontroller. This chip enables the computer to see the device as a virtual COM port, through which communication can be established in the same way as through a hardware COM port.

Microcontroller program consists of receiving and storing data from the receiving unit, sending the signal to the transmitting unit, and RS232 serial communication with the computer.

Signal receiving is performed in the interrupt routine of the external interrupt, which is invoked each time when the state on the external interrupt pin changes. The signal is stored through the time interval of a certain state on the external interrupt pin, as in the interrupt routine the time interval from the previous state change is written in the array each time the interrupt, i.e. the state change on the pin, occurs. As various remote controllers function based on different protocols and send messages of different length, the array should allocate enough memory to ensure that the complete message is stored. When the message is stored, the data from the array are sent to the computer via the serial communication, to enable storing of the message in a database on the computer.

Sending of the signal through the transmitting unit is performed through the opposite process. First the message to be sent is received from the computer, and is stored in a variable array. This message is identical to the one that the microcontroller sent to the computer when recording the message from the remote controller. The carrier frequency of the output signal is adjusted by the function generator of the microcontroller timer, and the signal itself is generated by turning on or off the output pin of the timer in the time intervals stored in the array that represents the message. As the frequencies of the signal changes are high, the microcontroller cannot simultaneously send and receive data, but can be in either receiving or sending mode. When the power is switched on, the microcontroller is in receiving mode, and stays that way until it receives a command from the computer to switch to the sending mode.

Microcontroller ATmega8 has an integrated support for RS232 serial communication, which is used in this case. It is necessary to set the communication speed, number of data bits, stop bits and the parity bit. The highest communication speed of 115200 bps has been chosen, which is possible as the external oscillator of 7.3728 MHz is used, furthermore, 8 data bits, one stop bit and no parity bit have been chosen.

IV. Application for Communication with the Infrared Transceiver

In order to connect the devices controlled by the infrared transceiver in one control system, an application in Visual Basic .NET has been developed for Windows operating system, which enables communication between the computer and the transceiver.

This application communicates with the transceiver through serial RS232 communication via the virtual COM port. The settings of the serial communication are: baud rate of 115200 bps, 8 data bits, 1 stop bit, no parity bit. Through serial communication, by sending a certain command, the user can set the desired working mode of the microcontroller (receiving or sending of infrared signal). If the microcontroller is in the receiving mode, it is possible to send a command from the application that enables reading of the message currently stored in the microcontroller. Then the message is stored in a data array on the computer, and can be drawn on the graph. Figure 7 shows part of the application which receives the message from the microcontroller, where one message record can be seen. The upper graph shows the recorded array itself, where each array element represents the length of the time interval between two state changes. The lower graph shows the data array transformed to the real signal. In the figure it can be noticed that for this remote control protocol it is possible to record five times the repeated message, while for some other protocols, in the same array it is possible to record the message only once. The recorded array can be saved in the database with adequate connection with the device name and the function to which this message applies.

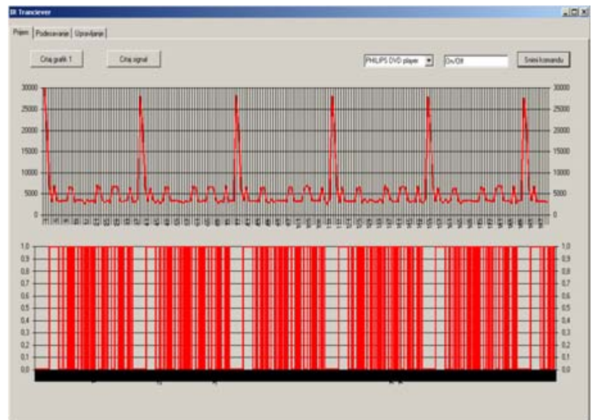

Fig. 7. Application for communication with the infrared transceiver (receiving part).

When the database has saved commands for a certain device, the application can be used to set the command to the microcontroller to change the mode to the sending mode, and to send the message to be sent from the transceiver and

perform a function on the end device (Figure 8). When transiting to the part of the application for device control, the command for switching to the sending mode is sent to the microcontroller. In this part of the application it is possible to choose the desired device from the database of available devices, and the function which should be performed from the list of saved messages. Then the message is stored in the temporary array, which is then sent to the microcontroller in the appropriate format, via the virtual COM port.

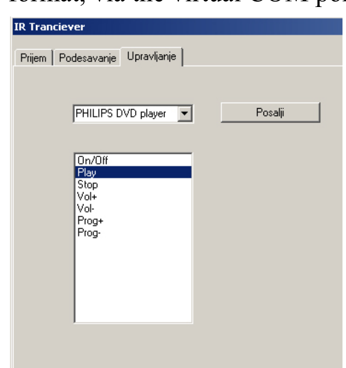

Fig. 8. Part of the application for sending commands.

In this application it is still required to provide the possibility to control the devices through the computer network, which would enable full automated control that could be realized even in the absence of the user. Furthermore, it is possible to add an application part for programming control in certain time, for example for setting the start and end of recording a certain program on the DVD recorder, turning on or off the TV or the audio device at a certain time, etc.

V. Conclusion

In home automation it is often required to integrate devices that have a built-in infrared receiver intended for remote control to an automated control system. In order to integrate such devices as easy as possible in a complete control system, it is possible to substitute the remote controller with another infrared transmitter which would automatically control the device.

In this paper an infrared transceiver is suggested, which connects with the computer via the USB interface. This transceiver can store commands from the existing remote controller, send them to the computer where they are stored in an adequate database, and on request it can also send commands to the transmitting unit. As most of the devices widely used, use infrared signals with a carrier frequency of 38 kHz, the solution in this paper can be implemented for control of common TV, video and audio devices in a home. Such a transceiver can completely substitute the existing remote controller and provide simple control of devices, even in the user absence.

The advantage of using such a transceiver is that it does not depend on the protocol used by the device for communication with the remote controller, but only on the carrier frequency, as the command is stored in the form as it is being sent from the original remote controller, and in that form it sends the command when requested.

The disadvantage of using such a transceiver in home automation is the request for optical visibility between the transmitter and the receiver on the device, so in the case of controlling multiple devices, more transmitting diodes must be implemented, where each would point the adequate direction.

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