VLC technology data transfer based on microcontroller STM32

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***Abstract*—The paper proposes a data transmission system using white LEDs. This technology uses a microcontroller series STM-32. The transmission uses digital pulse-frequency modulation to encode the binary system. The modulation is implemented using the digital output of the microcontroller. The proposed scheme has allowed to transfer character data with a frequency of 10-3 s. In the period of the improvement of the proposed scheme, the data transmission speed can be increased significantly and to communicate to the CPU clock.**

Keywords—microcontroller, LED, modulation, VLC, generator, comparator, photo detector

I. Introduction

Today, VLC systems are considering by American developers led by Professor Thomas Little as a very valuable future generation of wireless communication systems that will surpass data systems in terms of data transfer speed, such as Wi-Fi connections, which today reach the 600 Mbps standard IEEE 802 [1]. The coding of data using VLC technology is carried out due to the quick, not perceptible to the human eye, turning off / on (blinking) a light source, which simultaneously performs the function of a lighting device. Visible light sources such as incandescent and fluorescent lamps cannot be switching quickly enough to provide high-speed transmission.

Scientists in many countries are beginning to develop data networks that use not radio waves, but visible light - and the most common LED bulbs [1-8].

Flickering of light, occurring with a high frequency, will allow you to transmit information without noticeable changes in the level of illumination of the room. “Imagine that your computer, iPhone, TV, radio and air conditioning can interact with each other and with you, anywhere in the room. To do this, just turn on the light - and not a single wire is needed,” explains Thomas Little.

VLC - optical wireless communication technology, which suppose the use of LEDs, promises high bandwidth [2]. From the works of Thomas Little you can see that at a maximum distance of 5 m, it is possible to organize a communication channel at a speed of 500 Mbit / s, protected from data interception and exposure to electromagnetic interference.

VLC systems use specific modulation schemes. To provide additional opportunities for modulation and signal determination in the VLC system, lamps equipped with multi-color LEDs can be used.

VLC can provide simultaneous access to the network to many users, as it is a sheer rock-band wireless technology. VLC technology can be implemented optical spatial multiple access scheme (Space Division Multiple Access, SDMA), when using angular diversity transmitters. Compared to time division optical multiple access (TDMA), SDMA can achieve a tenfold increase in throughput in a VLC network. Using OFDM provides a simpler multiple access method, i.e. orthogonal frequency division multiple access (OFDMA), in which users are served and shared by multiple orthogonal subcarriers.

VLC network performance can be improved by using NOMA non-orthogonal multiple access. Different from conventional OFDMA technologies, NOMA can serve an increased number of users through the allocation of non-orthogonal frequency resources.

Possible modulation types for VLC technology are presented in Fig. 1[3].

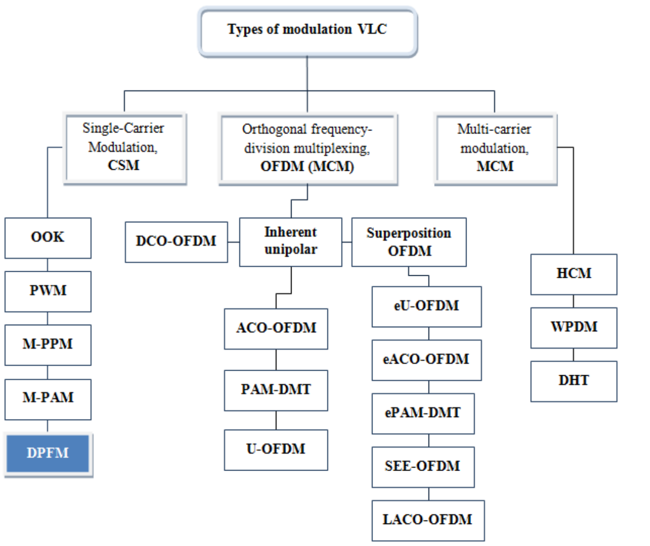

Fig. 1. Classification of VLC modulation methods

When modulating a single carrier (Single-Carrier Modulation, SCM) commonly used circuits include amplitude manipulation (On-Off Keying, OOK), pulse phase modulation (Pulse Position Modulation, PPM) and pulse frequency modulation (Pulse Frequency Modulation, PFM) pulse amplitude modulation (Pulse-Amplitude Modulation, PAM).

OOK is one of the simple modulation schemes, and provides a compromise between system performance and implementation complexity. OOK transmits data by sequentially turning the LED on and off, the circuit can provide support for reducing light intensity (dimming). Dimming by adjusting the levels of on and off of the LED can maintain the same data rate, however, the range and reliability of communication decrease with a low level of light intensity. And at the same time, dimming by means of symbol compensation can be achieved by inserting additional on and off pulses, whose duration is determined by the desired level of light intensity reduction. Since the maximum data transfer rate is achieved at a level of decrease in light intensity by 50%, assuming an equal number of ones and zeros on average, an increase or decrease in the brightness of LEDs

In this work, we used DPFM modulation, a type of pulse modulation in which the average value of the output parameter is controlled by changing the pulse repetition rate with a constant duration [11].

II. DEVELOPMENT OF THE TRANSMITTING AND RECEIVING PART OF THE SYSTEM

The information signal enters the VLC transmitting module via power lines (power lines) through a PLC modem, which extracts the information signal from the supply voltage. The transmitting module, in turn, includes a matching device, a modulator, an LED control device and an LED light source (Fig. 2)

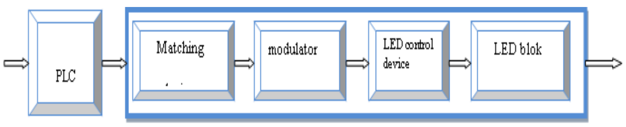

Fig. 2. VLC technology transmitter module circuit

The matching device brings the parameters of the signal from the modem output in accordance with the parameters required for controlling the LED modulator (comparing the parameters of the input signal with the parameters of the LED control device). The modulated signal is fed to the LED control device, which is a board containing a microcontroller, which controls the brightness, flicker frequency and the selection of the necessary LEDs from the unit.

Development of the receiving part of the system. The VLC technology receiving module is a small unit based on a photodetector (Fig. 3).

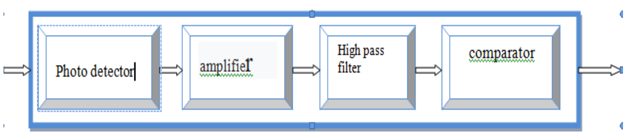

Fig. 3. VLC technology receiving module circuit

From the photodetector output, the detected signal goes to a low-noise amplifier and a filter to minimize noise. As a rule, the noise in a VLC receiver is similar to the noise of a conventional optical receiver from a communication line. This may be thermal noise from the load resistor and photodiode, excess noise from the amplifier, shot noise, as well as any other light sources in the room.[12]

The processed signal is fed to the input of a comparator, which converts the received analog signal into a digital sequence. The developed structure implements simplex mode. To implement duplex mode, the circuit is supplemented by a symmetrical channel.

Fig. 4 shows the transmitting part of the modulator, which includes a clock, counter, multiplexer, LED panel, STM 32 microcontroller and the receiving part of the device.

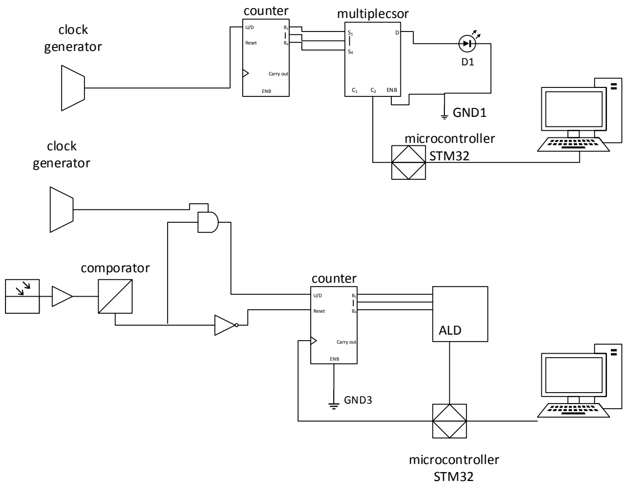

Fig. 4. Scheme experimental setup

A solar panel is installed at the reception, the signal received from the solar panel to the amplifier is transmitted to the comparator where the elements are compared and fed to the counter through the inverter and through the "AND" element are sent back to the counter of the receiving device. From the counter, the signal passes to an arithmetic - logic device, in which the variables are compared according to this algorithm: if $0 \leq X \leq 3$, then 0, if $3 \leq X \leq 6$, then 1, if $6 \leq X \leq 10$, then 2, if $10 \leq X \leq 18$, then 3.

III. FIELD STUDY RESULTS

The appearance of the experimental layout is shown in Fig. 5.

1-PC, 2,3- microcontroller STM32, 4-solar battery,5-led, 6-front panel screenshot, 7 – screenshot from the transmission panel

Fig. 5. Appearance of the experimental layout

The program for implementing data transfer using white LEDs is written in the Python programming language. Fig. 6 shows a block diagram of a program.

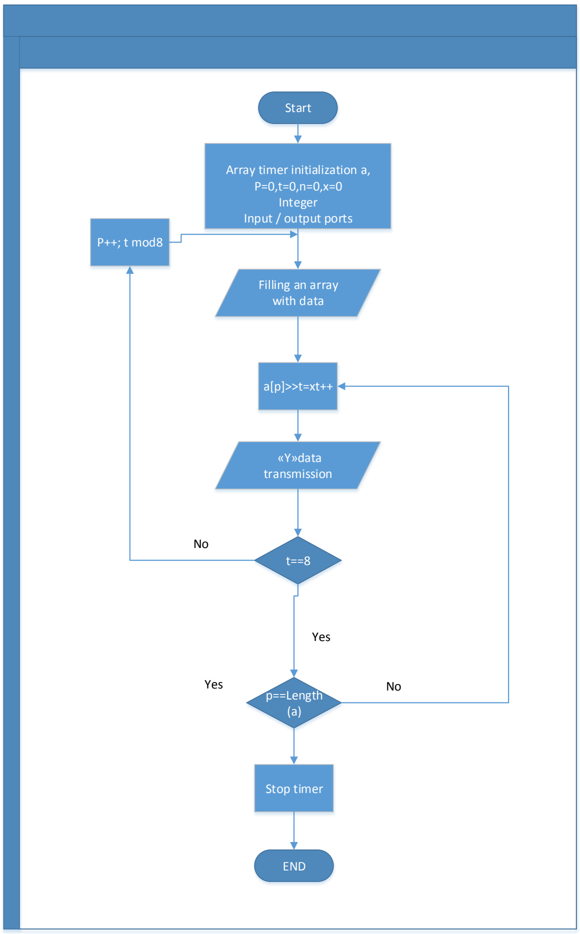

Fig. 6. Block diagram of the program

When the application starts, the following actions occur:

1. Initializing a timer, array a, P=0,t=0,n=0,x=0,

Input / output ports.

2. Filling the array with the data to be transmitted

3. Starting a timer to call the Send function.

The program exits either after the message arrives, or during the execution of the Send functions, which are responsible for the operation of the modulator.

The project file is called Pasha. Python is a light stream data transfer application. It initializes, processes events, calls the "Send" functions.

1) transmitted bit of the array a = a[p]>>t

2) number of steps (k+1)2=i

3) Describing the While loop N<i

X=(n//(k+1))

The resulting x value is sent to the LED

4)

if (t>=7)

{

if (p>= (array length a)-1)

{END}

Otherwise {p=p+1;}

}

Otherwise{t++;}

According to this algorithm, symbol data is transmitted.

Conclusion

As a result of the operation of the data transmission system using lighting LEDs, symbol variables were transmitted. At the same time, the proposed modulated light technique allows increasing the data transfer rate up to 5 Mbit per second using the STM-32 microcontroller. The proposed data transmission system can be used to monitor and control various technological processes.

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