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The Influence of the Spectral Components of Backlight on the Basic Camera Characteristics

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Abstract

The goal of the work is to determine the possibility of increasing the noise immunity of video cameras in the dark by using of non-conventional lighting devices. The methodology of the study is to apply an integrated approach based on subjective and objective quality assessment methods for television images and basic parameters of cameras. This article gives information about results of experimental studies to determine the technical characteristics of video cameras by using different types of lighting. The analysis of the results of the study showed improvement in the main indicators of cameras using white light illumination produced on the basis of red, blue and green LEDs in the appropriate proportions. The novelty of the work is the using of the proposed illumination device, which allows to increase camera sensitivity in the 0.2 - 0.6 Lux compared to conventional lighting devices.

Keywords: Quality of video, spectrum of lighting, video camera technical characteristics, signal processing, improving noise immunity.

INTRODUCTION

The camera is designed for day and night observation for outdoor or indoor usage in low light. During the daylight video cameras provide the transfer of the color image. During night when there is not enough light, camera automatically switches to night mode [1]. Currently applied specifications called IR illumination or lights red glow, maintains or improves the sensitivity of the video camera at night, but transmits only in black and white. In this case image is obtained with the help of IR illumination is slightly different from a video made by using illumination of the visible spectrum. Facial features when using IR illumination often appear distorted, making it ineffective [2].

Apart from general deterioration of definition occurs at night and additional defocusing different distance of objects, images that day were clearly focused. Defocusing occurs not only due to the reduced depth of field at full aperture, but also due to changes in the spectral composition of the light source (sun or artificial light). Especially strong defocusing occurs at night when using IR illuminators [3].

The main advantage of infrared backlight is invisible to human eye. As the concealment of the infrared light, visibility zone camcorder decreases. However, as IR becomes more covert it becomes more difficult for the camera to see and consequently distances are reduced. 940 - 950 nm IR (invisible to human eye) should only be used with highly sensitive cameras fitted with high performance lenses. Focusing is also more difficult at those wavelengths as lenses start to operate more inefficiently with 940 – 950 nm [4]. The usage of IR backlight makes detected human face different from image received by using visible spectrum of backlight.

In addition, characteristic of cameras with infrared illumination are reflection and backscattering from the environment (air dust, raindrops, snow, fog) [5].

METHODS

Methodology for the study is based on subjective methods of visual assessment of television picture quality in accordance with GOST 26320-84 [6], the recommendations of the ITU-R BT 500-11 [7] and the objective (instrumental) methods of control the main characteristics of video cameras in accordance with GOST 51558 -2000 [8].

MAIN PART

The quality of video camera is determined by a number of indicators, but in most cases, when you select the camera for a particular system is sufficient to focus on GOST R 51558-2000, which provides for a mandatory entrance test three specifications camera such as resolution, the working range of illumination (sensitivity) and S/N ratio. During the experiments, more attention is paid to the sensitivity, as it affects the sensitivity of the camcorder image quality in low light (in twilight or darkness).

The aim of this work is to determine the dependence of the main characteristics of video camera from the spectral components of the backlight and the definition of the

possibility of using the backlight of the visible. The experimental part of the work was conducted in the laboratory of video surveillance systems Almaty University of Power Engineering and Telecommunications. Experimental program included next steps:

- verification of compliance with the characteristics of different types of video cameras under normal lighting conditions (without dimming);
- checking the characteristics of video cameras in the shadow box using different lighting options (infrared, red, orange, green, blue, purple, white).

To estimate the parameters of the video-signal of the experimental studies were carried out on the installation of the transmitted signal, shown in Figure 1. The shadow camera is equipped with blackout curtains (which are not shown in the figure stand), allows you to create the desired lighting level (or dimming) inside the shadow of the camera. In accordance with the light sensitivity characteristic it had to be removed and the remaining (main) characteristics of video cameras - resolution and signal / noise ratio. On the left wall of the underground chambers are elements of illumination.

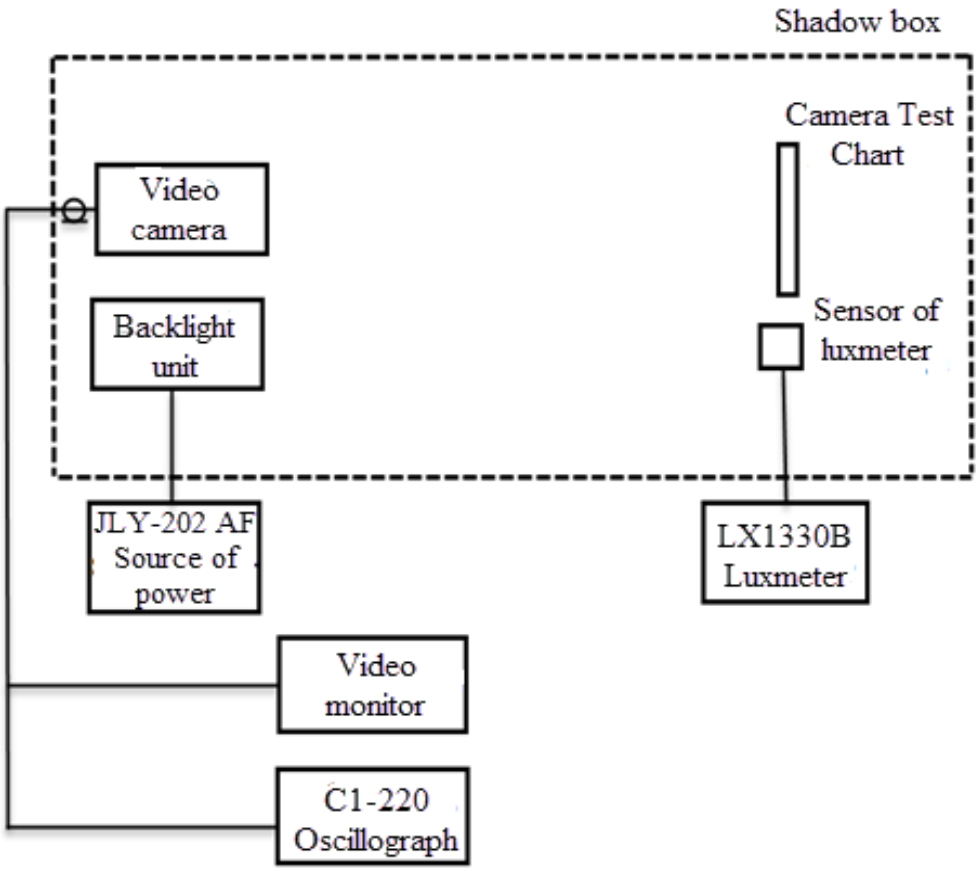

Figure 1: The overall block diagram for experimental studies

Power supply with 12V DC output voltage was intended in order to allow make an experimental research with different types of cameras. The experiment was conducted using four models of camcorders - TAT-603S, JN-2019P, VHT VC45B-230 and QIHAN QH-1139C-3 at a resolution of 380, 420 and 600 TVL. The main technical characteristics of video cameras are shown in Table 1.

During the experiments a video monitor, an oscilloscope C1-220 source JLY power - 2002AF, LX1330B light meter and backlight unit in the form of light-emitting diodes of different wavelengths were used (Figure 2). It involves the usage of 8 types backlight (infrared, red, yellow, green, blue, violet, ultraviolet, and white), but the type of ultraviolet illumination, unfortunately, was not found.

For experimental studies it became necessary to use a simple video camera lighting device capable of emitting white light in a wide range of color temperatures and based on RGB (red, green, blue) light-emitting diodes.

Table 1. Main specifications of used cameras

Model	JN-2019P	VHT VC45B-230	TAT -603S	QIHAN QH-1139C-3
Image Sensor	1/4"SHARP	1/3"	1/4"SHARP	1/3"DIS
System of Signal	NTSC, PAL	Black and white	NTSC, PAL	PAL
Horizontal resolution, TV lines	420 TV lines	420 TV lines	380 TV lines	600 TV lines
Minimum illumination	0.5 lux/F1.2	0.03 lux/F1.4	0.8 lux/F1.2	0.3 lux (IR is on)
Signal/Noise ratio, dB	48dB	50dB	48dB	48dB
Gamma correction	0.45	0.45	-	-
Operation temperature, °C	-10°C ~ 50°C	-10°C ~ 40°C	-10°C ~ 50°C	-10°C ~ 50°C
Built-in lights	Absent	Absent	Absent	Off

RESULTS AND DISCUSSION

Figures 2-3 present the results of experimental studies in the form of diagrams of the output signal depending on which has been removed from the oscilloscope on the light, fixed by light meter, using a variety of illumination options. In addition, the image quality was monitored on a video monitor.

By comparing the output voltage depending on the different types of cameras with its different resolution, it can be seen that the sensitivity of the test cameras significantly lower than specified, and "black-and-white camera, as a rule, has higher sensitivity than the color one" [9]. This is due to the fact that in most cases significant sensitivity of monochrome camera (compared to the human eye) is shifted in the infrared range. Some modifications of the sensitivity in the near infrared range is even higher than in the visible. The spectral sensitivity of color cameras is the same as the human eye [10].

The fundamental factor limiting the sensitivity of any camera is the noise, having at least two sources: the quantum noise of light structure and the inherent noise of the camera. In an ideal television camera its sensitivity depends on the photon noise - fluctuations in the number of photons with respect to the mean. It is for these reasons that camcorders sensitivity is lower than specified.

Results of the study (Figures 2 and 3) confirmed that the sensitivity of the camera is higher when we use infrared illumination and red color. White spectrum of light-emitting diodes provides the worst sensitivity of video cameras. The reason is that "artificial light sources have different color temperatures, depending on the source [1]".Also some inconsistencies in the chain “the source of illumination - matrix – display” decrease the value of basic indicators of the camcorder.

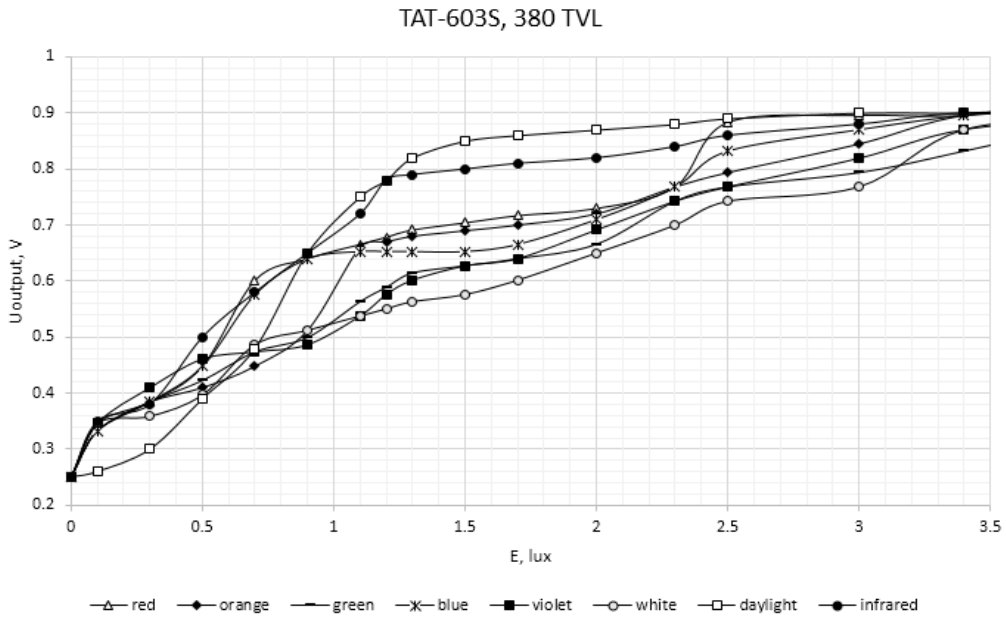

Figure 2: The dependence of the output voltage from the brightness of the subject with different spectra of light for a color video camera TAT-603S, 380 TVL

According to [11], the lighting system, which consist of only white light-emitting diodes will have restrictions by color temperature, however, it will provide a sufficiently high color rendering index (CRI), compared with the systems organized by mixing colors to create white light. So far as the color depends on the ratio of the color spectrum of light-emitting diodes, the greater the number of different spectrum LEDs is used, the higher CRI will be.

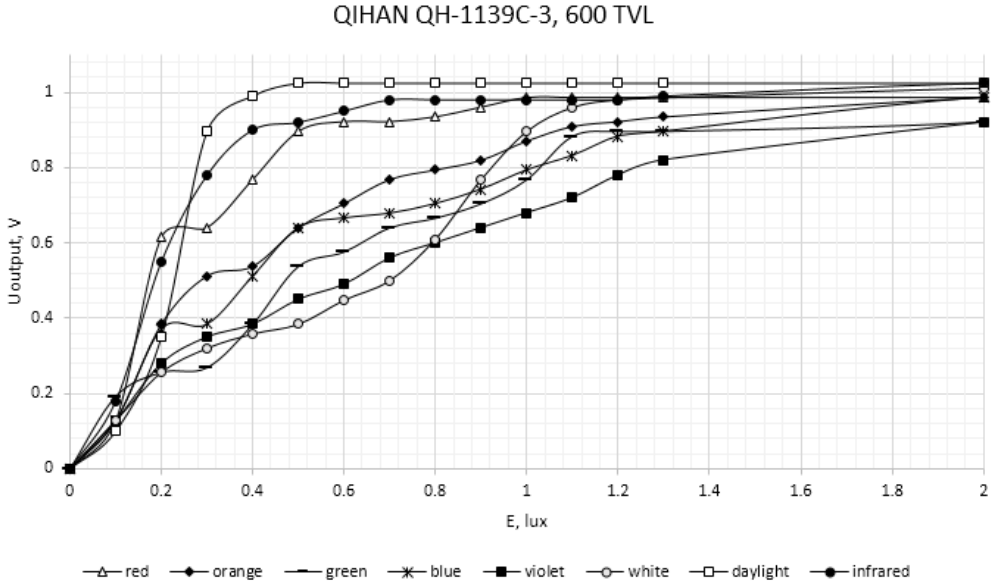

Figure 3: The dependence of the output voltage from the brightness of the subject under different spectra of light for a QIHAN QN-1139C-3, 600 TVL color video camera

On the basis of the above statement, experiments were performed (Figure 4), is to compare the levels of the output signals obtained from the using of different types of source of illumination in white (white spotlight, LED white, RGB LEDs and fluorescent lighting).

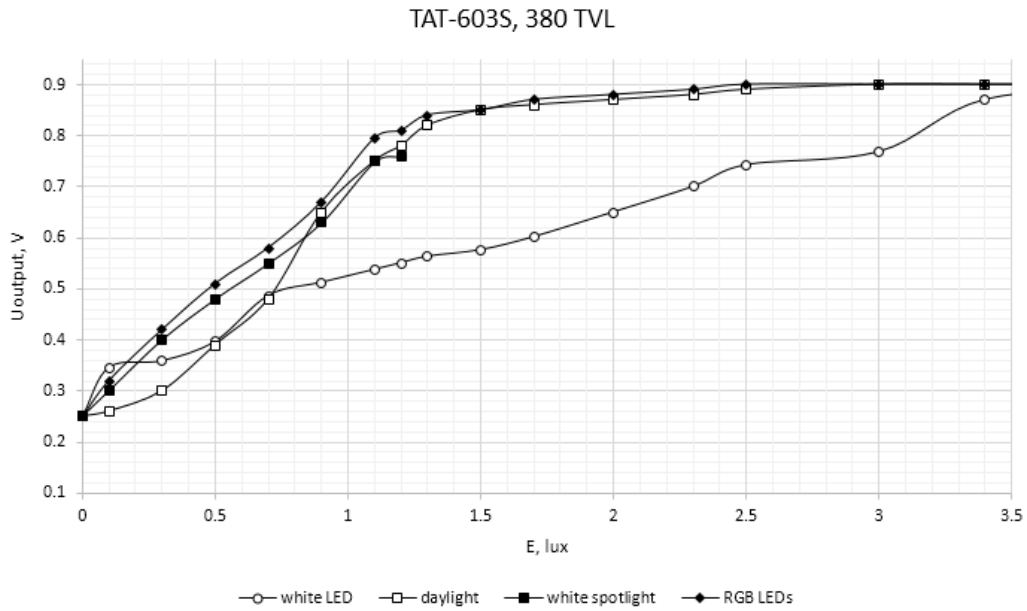

Figure 4: The dependence of the output voltage from the brightness of the subject under different lighting sources for a TAT-603S, 380 TVL color video camera

Figure 5 shows the output level removed from the oscilloscope and test table from using white light illumination on the basis of RGB light-emitting diodes in a darkened chamber.

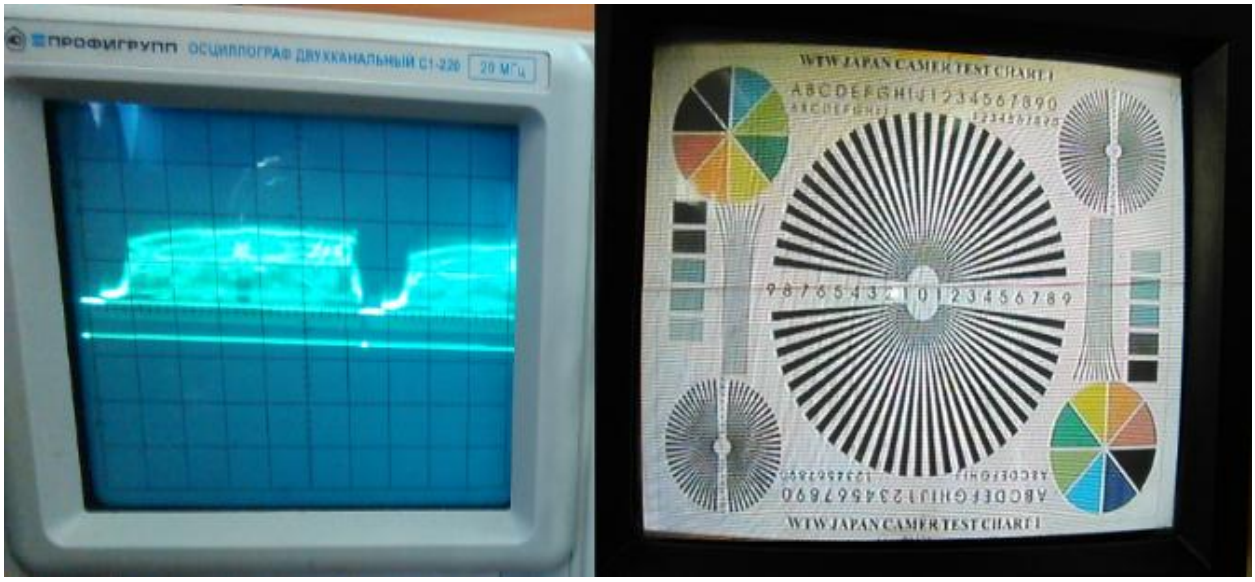

Figure 5: The combined using of a visual (on the right) and the tool (left) control methods for the test table obtained from the monitor by using a TAT-603S, 380 TVL color video camera at illumination with RGB LEDs

The results of the experiment (Figures 2-4) showed that the addition of RGB colors makes the final color brighter. At the same time, to get the white color, there must be present all three colors in the appropriate proportions. Picking up three components of RGB LEDs in the correct proportions, we have increased the sensitivity of the camcorder 0.2 -0.6 Lux and save the image color in the dark. Increased brightness RGB LEDs due to the increase in their number leads to a further increase in the sensitivity of the camcorder while preserving image color. Apart from that, for a given (improved) sensitivity, key indicators, namely, resolution and signal / noise ratio, has not changed for the worse.

CONCLUSION

In order to provide camera`s operational capability in dark time devices of the local IR LED and IR illuminators are currently used. However, IR illuminators are quite expensive and at night provide transmission of black and white images only. The using of lighting with RGB LEDs allow to increase the sensitivity of the video camera (in the case of this experiment 0.2 -0.6 Lux)by maintaining the color image in the dark and even exceeding the parameters of the backlight in the form of regular white light spotlight.

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