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Satbayev University

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ИЗВЕСТИЯ

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РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

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AMPLIFIER DESIGN FOR MODELING THE TRANSMISSION OF A DIGITAL VIDEO SIGNAL OVER A DATA TRANSMISSION CHANNEL

Abstract. The use of video surveillance systems is used in the areas of security, law and order, in the territories of protected objects, in monitoring the movement of road vehicles and in other areas.

The main disadvantage of a video surveillance system is its susceptibility to weather influences (rain, fog, snowfall, etc.), which degrades the quality of the video system by reducing the signal level.

Therefore, the urgency of finding new ways and possibilities to improve the quality of video signals is one of the priority areas of signal processing. The main task of this work was to determine the main parameters, simulate the transmission line and amplifier, and select the schematic diagram of the transmitting and receiving path with the voltage and current ratings.

Both the receiver and the cable video transmitter have different means of adjusting to different transmission line lengths. The signal at the output of each receiver should be in the range from 0.9 to 1.1 V, and the spread of the total ohmic resistance of the wires of the video transmission line at the input of the receiver should be no more than 2 – 3%. Based on these parameters, the equipment is configured for transmitting video over the channel. The magnitude of the mismatch is regulated by potentiometers, which allow smooth adjustment of the video transmission equipment [1].

As a rule, video transmission over the channel is carried out at a distance of 50 to 1500 m. If it is necessary to transmit video at distances less than 50 m, additional resistances are connected in series at the receiver input so that the total line resistance is 30 - 50 Ohm [1].

Key words: data transmission channel, video surveillance, television signal, operational amplifier.

Video surveillance systems are used in the sphere of law enforcement, on the territories of protected facilities, for monitoring the movement of vehicles and in other areas.

The main disadvantage of a video surveillance system is its vulnerability to weather conditions (rain, fog, snowfall, etc.), which degrades the quality of the video system by reducing the signal level.

Therefore, the urgency for finding new ways and possibilities of improving the quality of video signals is one of the priority directions of signal processing. The main task of this article is to determine the main parameters, to model the transmission line and amplifier, and to select a basic circuit of the receiving and transmitting path with voltage and current ratings.

Both video cable transmitter and receiver have different settings for various transmission line lengths. The signal at the output of each receiver should be in the range from 0.9 to 1.1 V, and the value deviations of the total ohmic impedance on the video transmission line cables at the receiver input should not exceed 2 – 3 %. Based on these parameters, the equipment is configured to transmit video over the channel. The magnitude of the mismatch is regulated by a potentiometer that allows performing a smooth hardware configuration of the video transmission [1].

As a rule, video transmission over the channel is carried between 50 and 1500 m. If it is necessary to transmit video over distances less than 50 m, additional impedances are sequentially turned on at the receiver input so that the total line impedance becomes 30 – 50 Ohms [1].

The stray capacitance of the line is compensated by special jumpers in the receiver. The level of compensation for the stray capacitance of the video transmission line is selected individually for each transmission line based on the video picture on the test monitor. Also, using a test monitor or an oscilloscope, the receiver is configured according to the amplitude of the output signal.

Using a multi-channel video receiver to improve the parameters of the received signal, it is sometimes advisable to connect monitors to the receiver outputs via an impedance series of 51- 82 Ohms.

In addition to interference from radio apparatus and power lines, sometimes the video transmission line is affected by electromagnetic interference received as a result of a lightning discharge. Such interferences can be quite strong, as a result of which the equipment for transmitting video through a twisted pair will fail. To avoid damage, it is necessary to use lightning protection on the video channel transmission lines.

Figure 1 shows a typical circuit for switching on a differential amplifier. It can be used as a video signal booster. In this circuit, the amplification factor is calculated using the formula:

$$K = \frac{V_{OUT}}{V_{IN}} = \frac{R_F}{R_G},$$

where V_{OUT} is the output voltage, V; V_{IN} – input voltage, V; R_F – feedback impedance, Ohm; R_G – input impedance of the circuit, Ohm.

Resistors R_0 help keep the amplifier in a stable state. It is recommended to select resistors with at least a nominal accuracy of no more than 0.1 %.

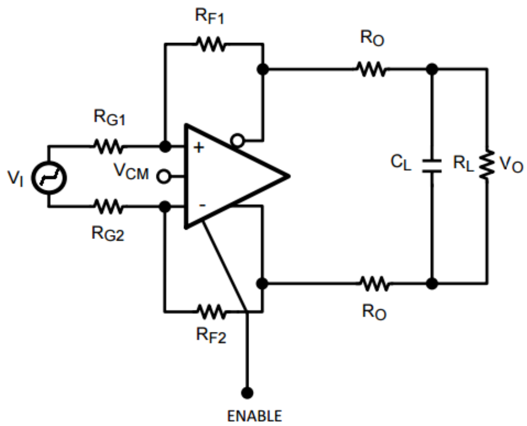

Figure 1 – A typical circuit of the amplifier switching

A high-speed broadband amplifier is the main component for transmitting a video signal over a data transmission channel. As a digital signal amplifier, the MAX403 OP-amp from the "Maxim Integrated Products, Inc" was selected, which was chosen as the most suitable for all requirements after careful analysis with analogues of this type of OP-amp.

Modeling the amplifier and transmission line.

The simulation results in OrCAD 9.1 for resistor impedances and long line values on a twisted pair are shown in figure 2.

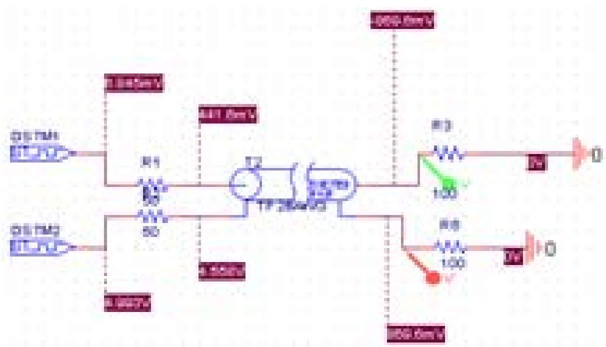

Figure 2 – Transmission line modeling

With a line length of 100 meters, figure 3 clearly shows signal delays of 0.62 µs. The signal is clear, its amplitude is about 1.5 V.

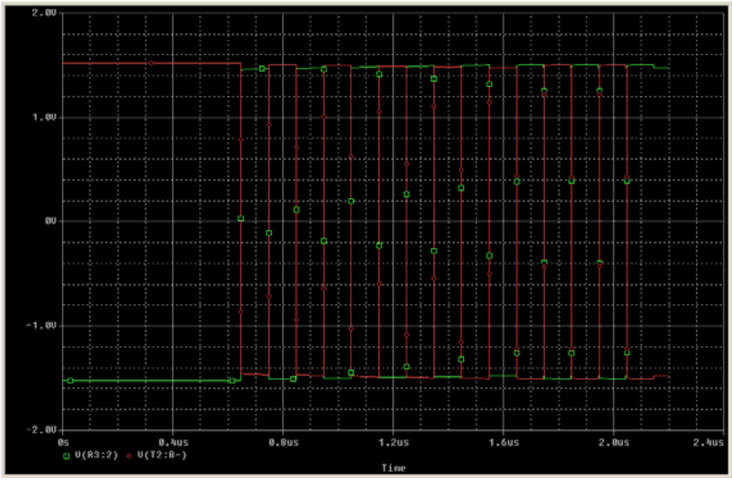

Figure 3 – Diagrams of antiphase signals U(R3; 2) and U(T2; B-) at the output of a long line of 100 meters on the same scale

There is the second signal in the opposite phase after the amplifier, which is clearly visible on the oscillogram. Figure 4 shows the signals transmitted through a 200-meter line.

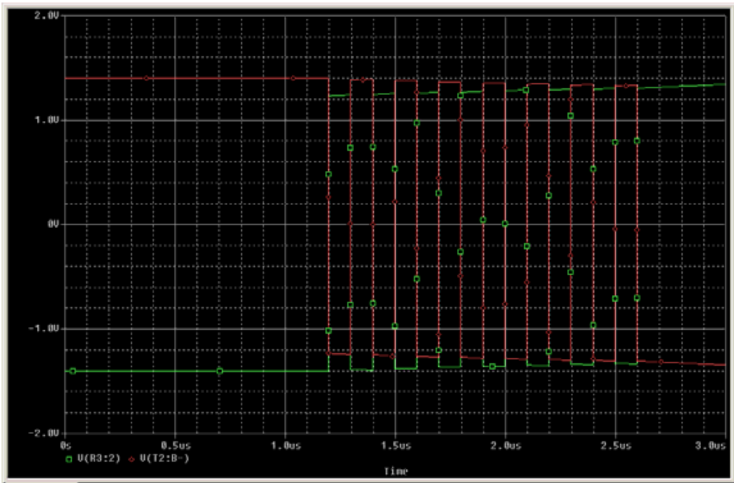

Figure 4 – Diagrams of antiphase signals U(R_3; 2) and U(T_2; B-) at the output of a long line of 200 meters on the same scale

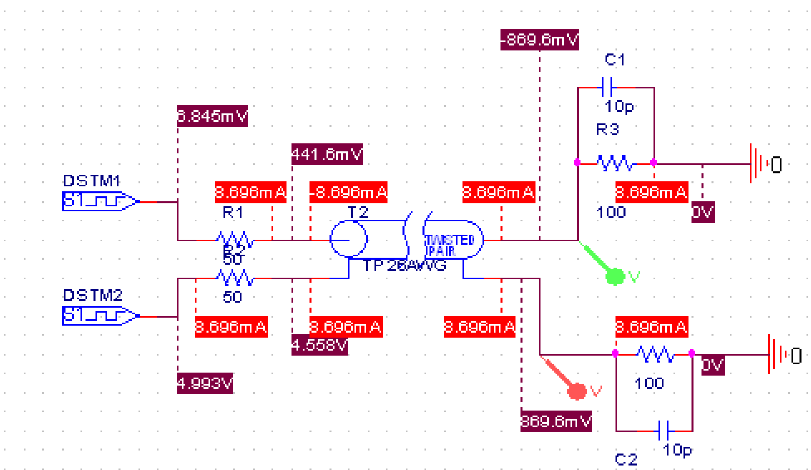

Figure 5 – Voltage and current ratings of circuit components

On a 200-meter line, we would like to note that the signal delay had increased to 1.2 µs. The signal amplitude had decreased to 1.4 V. Each pulse is distinct, but it is noticeably declining.

Figure 6 shows peaks in the signals U (R_3; 2) and U (T_2; B , which occur when a 10 pF capacitors are inserted to load the circuit. Small bursts (peaks) are noticeable at 0.75, 1.85, and 2.05 µs for the U (R3; 2) signal and for the U (T2; B-) signal at 0.75, 0.8, 1.75, 1.95, and 2.15 µs.

Similar measurements were also made for lines from 300 to 1000 meters with 100 m increments.

After receiving the simulation measurement data, the following results were obtained at a speed of 10 Mbit/s and a speed of 100 Mbit/s; it is summarized in tables 1 and 2.

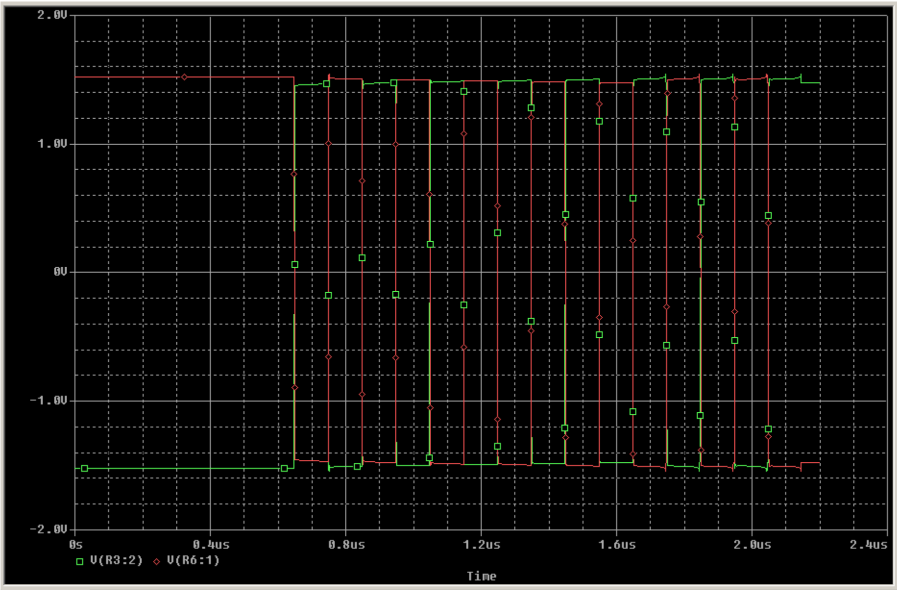

Figure 6 – Diagrams of antiphase signals U(R3; 2) and U(T2; B-) at the output of a long line of 100 meters with capacitive parameters on the same scale

Table 1 – Video signal transmission performance at 10 Mbit/s

Characteristics	Measurement data									
Line length, m	100	200	300	400	500	600	700	800	900	1000
Signal amplitude, V	1,5	1,3	1,2	1	0,9	0,8	0,7	1,2	1,1	1
Signal delay, µs	0,65	1,2	1,75	2,3	2,85	3,4	3,95	4,5	5,2	5,59

Table 2 – Video signal transmission performance at 100 Mbit/s

Characteristics	Measurement data		
Line length, m	100	500	1000
Signal amplitude, V	1,5	0,9	1
Signal delay, µs	559	2750	5490

Devices that use fully differential amplifiers have certain specifications. The main requirements are high linearity and the necessary signal amplitude. Linearity is achieved by using a well-chosen feedback line and setting the amplification factor by means of resistors, as well as appropriate supply voltage. The signal amplitude can be adapted using the appropriate amplification factors. The MAX403 operational amplifier, which was selected for the simulation, requires the installation of bypass capacitors of 0.01 and 0.1 µF. All capacitors must be grounded. Sinusoidal noise output can lead to loss of dynamic range and increased distortion. In addition, capacitive loads must be isolated from the amplifier output by small-value resistors. This is particularly true when the load has a resistive component that exceeds 500 Ohms. A typical A/D converter has a capacitive element of about 10 pF, and the component can be resistive for over 1000 Ohms. During transmission over a data channel, such as a coaxial one, the resistive component will be 50 Ohms; over a twisted pair it will be 100 Ohms. The usage of appropriate resistors will be sufficient to isolate any subsequent capacitance [5]. The supply voltage is set to +12 V and – 12 V, the general output mode is 0 V [4]. The basic circuit of the receiving and transmitting path is shown in figure 7.

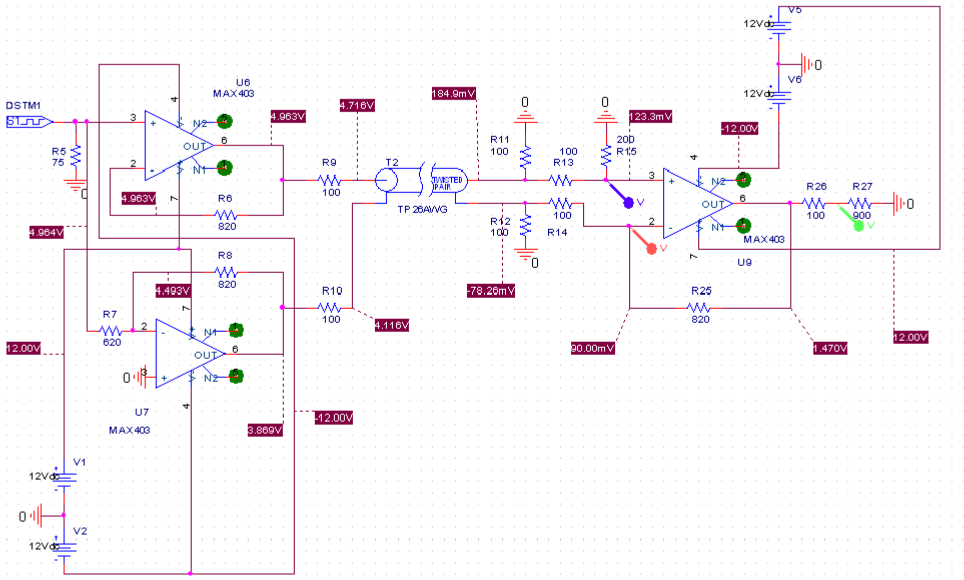

Figure 7 – Basic circuit of the receiving and transmitting path with voltage and current ratings

One of the simulation results is shown in the figure 8.

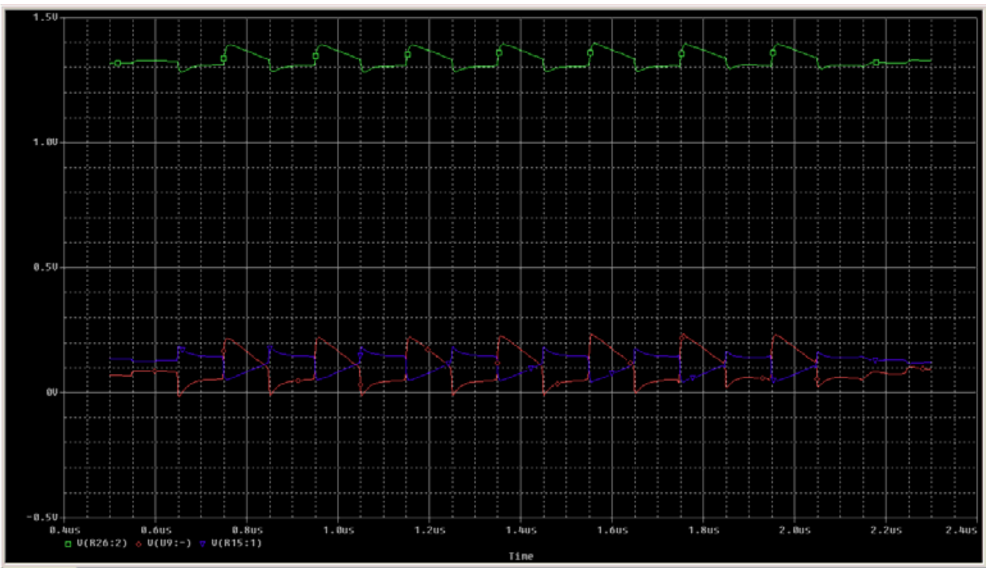

Figure 8 – Diagrams of antiphase signals U(U$_9$; N) and U(R$_{15}$; 1) at the output of a long line of and output signal U(R$_2$; 2) at 100 Mbit/s on the same scale

During a change of the data transfer rate over the TP26AWG twisted pair cable, there was a noticeable variation in the signal level and delay. With an increase in the signal transmission rate compared to 10 Mbit/s, no significant changes in the amplitude were noticeable, but the signal delay was significantly reduced up to 10^{-3} seconds.

Conclusions. The long line based on a twisted pair TP26AWG and MAX403 operational amplifier was selected. The signal delay was reduced to 10^{-3} seconds. The signal amplitude became about 1 V, which allowed us to completely restore the received signal at the reception. Data transmission was simulated at 10 Mbit/s and 100 Mbit/s, which fully allowed transmitting a digital signal over a distance of more than half a kilometer with acceptable distortion.

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ҚАУІПСІЗДІК ТЕЛЕДИДАРЫНДАҒЫ БАЙЛАНЫС АРНАСЫ АРҚЫЛЫ КАМЕРА МЕН МОНИТОР АРАСЫНДАҒЫ САНДЫҚ СИГНАЛ КҮШЕЙТКІШІН ЖОБАЛАУ

Аннотация. Бейнебақылау жүйелерін пайдалану қауіпсіздік, заңдылық, құқық қорғау орындарында, күзетілетін нысандар аумағында, жол көлік құралдарының қозғалысын бақылау кезінде және басқа жерлерде қолданылады.

Бейнебақылау жүйесінің басты кемшілігі – ауа райының әсеріне бейімділігі (жаңбыр, тұман, қар, т.б.) әрі бұл сигнал жүйесін азайту арқылы бейне жүйесінің сапасын төмендетеді.

Сондықтан бейне сигналдар сапасын жақсартудың жаңа жолдары мен мүмкіндіктерін іздеудің өзектілігі – сигнал өңдеудің басым бағыттарының бірі болып саналады. Жұмыстың негізгі міндеті –негізгі параметрлерді анықтау, электр беру желісі мен күшейткішті имитациялау және кернеу мен ток көрсеткіштері арқылы беру және қабылдау жолының түбегейлі схемасын таңдау.

Қабылдағыштың да, кабельдік бейне таратқыштың да тарату желісінің әр түрлі ұзындығына арналған әртүрлі реттеу құралдары бар. Әрбір қабылдағыштың шығысындағы Сигнал 0,9-дан 1,1 В-қа дейінгі диапазонда болуы тиіс, ал қабылдағыштың кіреберісіндегі бейне беру желісі сымдарының жиынтық омдық кедергісінің шашырауы 2-3% - дан аспауы тиіс. Осы параметрлерге сүйене отырып, жабдық бейнені арна арқылы жіберуге бейімделеді.

Сәйкессіздік потенциометрлермен реттеледі, бұл бейне сигнал беру жабдықтарының жұмысын біркелкі реттеуге мүмкіндік береді [1].

Әдетте, канал арқылы бейне беру 50-ден 1500 м-ге дейінгі қашықтықта жүзеге асырылады. Егер бейнені 50 м-ден аз қашықтықта жіберу қажет болса, ресивер кірісінде қосымша кедергілер тізбектей қосылады, сонда жалпы сызық кедергісі 30 - 50 Ом болады [1].

Түйін сөздер: бейнебақылау, теледидарлық сигнал, жедел күшейткіш.

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ПРОЕКТИРОВАНИЕ УСИЛИТЕЛЯ ЦИФРОВОГО СИГНАЛА МЕЖДУ КАМЕРОЙ И МОНИТОРОМ ПО КАНАЛУ СВЯЗИ В ОХРАННОМ ТЕЛЕВИДЕНИИ

Аннотация. Применение систем видеонаблюдения применяется в зонах обеспечения безопасности, правопорядка, на территориях охраняемых объектов, при контроле за движением дорожных транспортных средств и в других зонах.

Основным недостатком системы видеонаблюдения является ее восприимчивость к погодным воздействиям (дождь, туман, снегопад и т.д.), что ухудшает качество работы видеосистемы за счет снижения уровня сигнала.

Поэтому актуальность поиска новых путей и возможностей повышения качества видеосигналов является одним из приоритетных направлений обработки сигналов. Основной задачей данной работы было опреде-

ление основных параметров, моделирование линии передачи и усилителя, а также выбор принципиальной схемы передающего и приемного тракта с номинальными напряжениями и токами.

И приемник, и кабельный видеопередатчик имеют различные средства настройки на различную длину линии передачи. Сигнал на выходе каждого приемника должен находиться в диапазоне от 0,9 до 1,1 В, а разброс суммарного омического сопротивления проводов линии видеопередачи на входе приемника должен составлять не более 2-3%. Исходя из этих параметров, оборудование настраивается на передачу видео по каналу. Величина рассогласования регулируется потенциометрами, которые позволяют плавно регулировать работу аппаратуры передачи видеосигнала [1].

Как правило, передача видео по каналу осуществляется на расстоянии от 50 до 1500 м. При необходимости передачи видеосигнала на расстояния менее 50 м на входе приемника последовательно подключаются дополнительные сопротивления так, чтобы общее сопротивление линии составляло 30-50 Ом [1].

Ключевые слова: видеонаблюдение, телевизионный сигнал, операционный усилитель.

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