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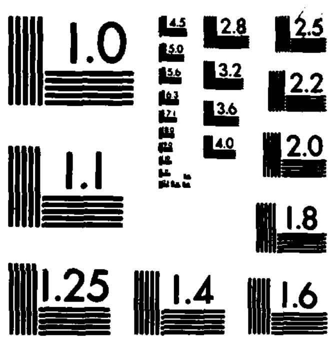

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COMPUTER OPTICAL FIBER DATA TRANSMISSION SYSTEM

by

Dong Weiguang, Hu Wenjin, et al.

FOREIGN TECHNOLOGY DIVISION

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COMPUTER OPTICAL FIBER DATA TRANSMISSION SYSTEM

Dong Weiguang, Hu Wenjin, Zhang Wenlan and Ren Keyun

I. INTRODUCTION

The signal bandwidth capable of being transmitted by an optical fiber is beyond comparison with that of a co-axial electrical cable. It not only can transmit high speed digital signals, but also can transmit wide bandwidth simulated signals. It is a new technology currently under development.

The use of optical fibers as the transmission lines between computers and other equipment has the advantages of no susceptibility to electromagnetic interference, electrical potential isolation and ease of long distance connection and matching. It is suitable for applications in an environment seriously affected by electrical interference, or on an occasion when potential isolation or electrical insulation is required. It not only can effectively solve some of the signal transmission problems encountered in computer application technology, but also can greatly improve the reliability of computer data transfer. Some of the experimental results in foreign countries led to the belief that using optical fibers to transmit data would be far more effective as compared to the present transmission methods.

This paper introduces optical fiber data transmission equipment used for computer output data transmission with a transmission rate of one million bits/sec which is 100 meters long. We used this device to connect the DJS-130 computer and the external output device. We carried out the output adjustment of experiments on a 100 kV high voltage stable power supply, 300 kV high voltage stable power supply and 100 A constant current power supply with a computer. Results obtained were successful.

This system was tested in a complicated electrical interference environment for over half a year, and the results were satisfactory.

II. OPTICAL FIBER, LIGHT SOURCE AND OPTICAL DETECTOR

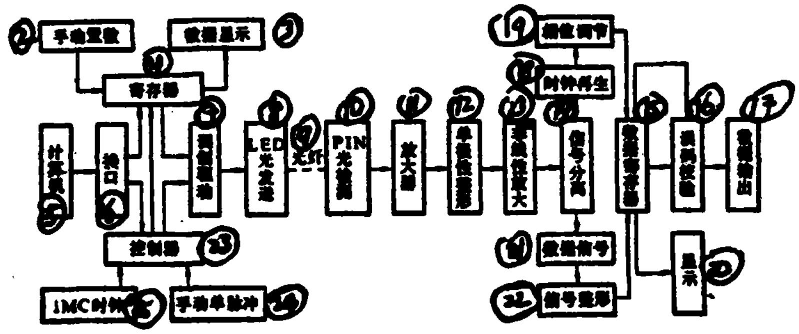
This system used was an optical cable formed by four step refractive index optical fibers which have a core diameter ϕ = 60 micron, a colored layer diameter ϕ = 180 micron, the numerical aperture N_A = 0.16, and the length L = 100 m. The incident light wavelength λ = 0.83 micron; the optical fiber loss is 1.83 dB/kilometer. The light source used was a gallium arsenide light emitting diode LED which emits photons spontaneously. Its light wavelength happens to be in the low loss range of optical transmission. In this system, due to the fact that the optical fiber length was only 100 meters, therefore, the driving current of LED was only 25-50 mA, and its rise time was 20 nanoseconds. The coupled end fiber output power was approximately 4 microwatts. If the optical fiber is increased to 1 kilometer, the driving current correspondingly can be increased to 200 mA. The end fiber coupled output power can be raised to 15 microwatts.

The connection between the LED and the optical fiber was made by burning the end of the optical fiber into a spherical lens. It enabled the coupling of the LED which had an optical scattering angle of 100-120° and the optical fiber which only had a 19.5° reception angle, so that the coupling efficiency could be improved by three times. This coupling problem is very important in long range optical fiber transmission. Usually, the connection between a flat optical fiber surface and the LED has a coupling efficiency of less than 3%.

The optical detector used was a silicon semiconductor photoelectric diode PIN. Its responding wavelength range is 0.8-0.9 micron and the response time is 1 nanosecond. The quantum efficiency is 50%. The quantum noise is small; however, the signal is also small. The signal-to-noise ratio is inferior to that of an avalanche photoelectric tube. However, the required power supply and circuit are simpler. Furthermore, it already can adequately satisfy the data transmission requirements.

III. WORKING METHOD AND STRUCTURE

The system uses the transmission method which involves the parallel transmission of data signal and clock signal by an optical fiber. The data signal and clock signal are used to excite the light source after modulation in order to obtain optical signals of various intensities. On the receiving end, the signal was amplified, modified, and underwent phase separation to obtain the original clock signal and data signal. The transmission rate of the system is 1 megabits/sec with a maximum (transmission rate) of 1.3 megabits/sec. It might be possible to use a manual low speed single pulse transmission mode. The block diagram of the system is shown in Figure 1.



① 图1 计算机光纤数据传输系统框图

Figure 1. The block diagram of the computer optical fiber data transmission system
2--manual data input; 3--data display; 4--storage; 5--computer; 6--linkage; 7--modulation drive; 8--LED light emission; 9--optical fiber; 10--PIN optical detector; 11--amplifier; 12--monopolar reforming; 13--nonlinear amplification; 14--signal separation; 15--data storage; 16--miscoding checking; 17--data output; 18--regeneration of the clock; 19--phase adjustment; 20--display; 21--data signal; 22--signal reforming; 23--controller; 24--manual signal pulse; 25--IMC clock

In the light emission part, the data output buffer storage with a displacement effect was used to send the data in series to the modulating and driving circuits under the control of a clock signal. In addition, the data signal and clock signal are mutually modulated

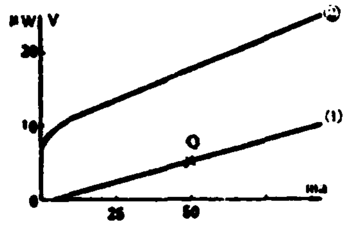


Figure 2. The correlation between the driving current and optical power of the LED

Figure 3. The voltage waveform of the light emitting LED

Figure 4. The clock data signal after rectifying amplification

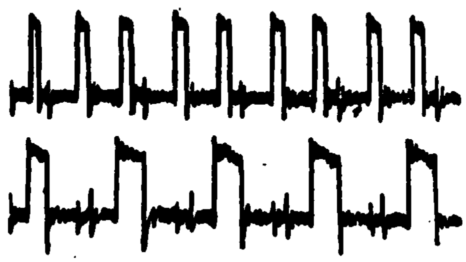


Figure 5. The regenerated clock and data signals

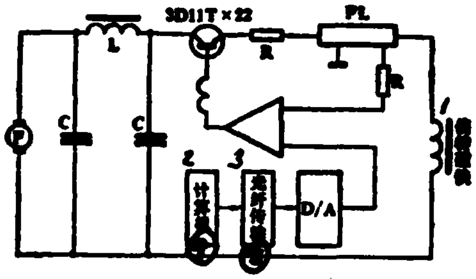


Figure 6. The control block diagram of a 100 A constant current supply
1--deflecting magnet; 7--computer; 8--optical fiber transmission

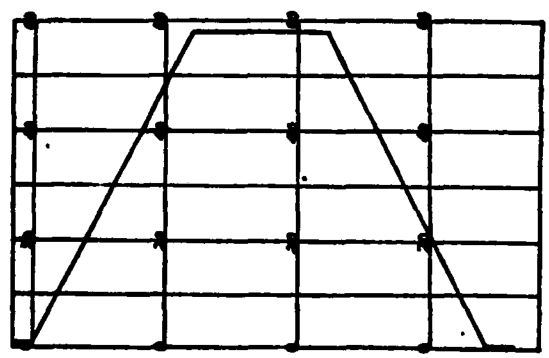


Figure 7. The current waveform of the output of the constant current supply

in the circuit. Then it is used to drive the LED to emit optical signals of various intensities corresponding to the data and clock signals. The OQ section of the correlation curve between the LED driving current and the optical power under the effect of the clock signal and data signal is shown as curve (1) of Figure 2. The modulated signal pulse width is about 400 nanoseconds. The voltage waveform of the LED is shown in Figure 3. Because it is a voltage waveform, therefore, the data signal and clock signal in the figure are shown as curve (2) in Figure 2 according to the current voltage correlation. The data stored in the output data buffer storage device can be manually placed or can be transmitted through the input program of a computer. When the DJS-130 computer is used to control input data, the computer executes the DOA command. At the W_0 bit, data is punched into the data buffer storage device from the parent line through the DRA signal. At the W_1 bit, the RCQD signal was started to transmit data. Output of data stored in the data buffer storage device can also be manually transmitted in order to facilitate the adjustment and inspection of the system.

In the light detection part, the optical signal sent into the PIN through the optical fiber is transformed into a bipolar electric signal by the PIN. This signal, after being amplified by a high input impedance amplifier, is amplified by a rectifying amplifier to form a monopolar signal. Its waveform is shown in Figure 4. Finally, the signal is amplified nonlinearly to facilitate the separation. In the signal separation stage, both the data signal and the clock signal are obtained. Through rectification and phase adjustment (see the waveform in Figure 5), they are sent to the data storage device formed by D flip-flops. Subsequently, the transmitted data is received on the receiving end.

The special feature of this system is that a parallel transmission working mode is used to transmit the data signal and the clock signal. The clock signal is used as a carrier wave. Hence, the bandwidth requirement of the frequency band of the receiving end of the circuit is reduced. In this system, as long as it is required that the

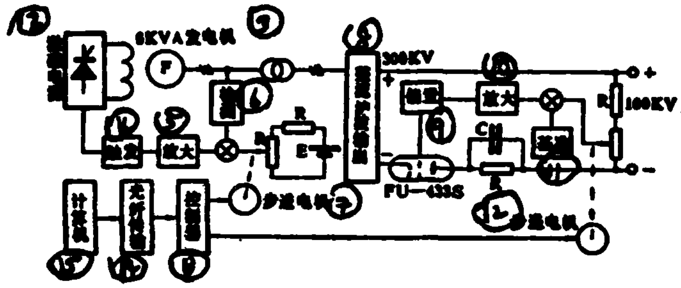


Figure 8. The block diagram of the output control of the 300 kV high voltage power supply and the 100 kV high voltage stable power supply
2--magnetically excited current; 3--6 KVA generator; 4--trigger; 5--amplifier; 6--detect; 7--step-by-step generator; 8--rectified and filtered wave output; 9--bias; 10--amplify; 11--base; 12--step-by-step generator; 13--controller; 14--optical fiber transmission; 15--computer;

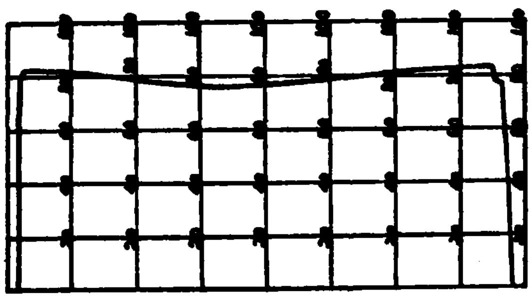


Figure 9. The output voltage waveform of the computer adjusted 300 kV power supply and the 100 kV stable power supply

receiving and can pass a signal bandwidth of 1 megaHertz, it is possible to realize the data signal transmission at various rates between 0-1 megabits/sec.

Next, this system has the capability to verify the miscodes transmitted. Despite the fact that the miscoding rate in optical transmission is very low, which is usually below 10^{-9}, the moscoding transmission effect still exists. By further considering the possible external interference introduced by the transmitting and receiving ends, it is necessary to discover a miscoded transmission in time in order to ensure the reliability of data transmission. For this purpose, this system is equipped with a verification code and an odd/even checking system. When miscoding occurs during transmission in the system, it is capable of eliminating the miscodes. Through the feedback system, the previous data command is reissued.

IV. THE COMPUTER CONTROL USING OPTICAL FIBER TRANSMISSION

The optical fiber data transmission system is used to connect the DJS-130 computer and the external output device to carry out the following computer controlled open loop experiments (because the various controlled systems are equipped with closed loop linkages, therefore, the open loop control mode is used).

1. The output control of a 100 A deflecting magnetic stable current power supply (Figure 6).

2. The output control of a 300 kV high voltage power supply (Figure 8).

3. The output adjustment of a 100 kV high voltage stable power supply (Figure 8).

The computer outputs digital signals. Through the optical fiber data transmission system and the output equipment, these signals reach the equipment under control. For the stable current power supply, the digital signal is used as the given signal after a D/A transformation. It is then used, together with the feedback current signal, as the two input signals of the comparator amplifier. After the comparative amplification, it is added to the base electrode of the rectifying tube. The rectifying tube is formed by 22 3DD11T tubes. Through the exciting magnetic coil of the deflecting magnet which is connected to the generator, the computer open loop control of the deflecting magnetic current is realized. The waveform of the current output is shown in Figure 7. The accuracy of current control is 0.05%.

For the 300 kV high voltage power supply and the 100 kV high voltage stable power supply, the digital signal is transmitted to the step-wise generator control circuit. The two step-by-step machines are controlled by the step-by-step control code. One of the step-by-step machines is used to drive the multiple coil potentiometer to adjust the magnetic exciting current of the 6KVA generator. Afterwards, through voltage transforming, rectifying and filtering, the 300 kV output voltage is obtained. In the experiment, a computer was used to control the output voltage of this power supply from 0 up to 100 kV. Then, the voltage stabilization link was added to use the other step-by-step machine to drive the sampling transformer on the high voltage end. The sampled signal was compared to the invariant base signal. After amplification, it is sent to the control grid of the FU-433S rectifying tube. The FU-433S tube works in the negative grid bias amplifying zone. The voltage of the tube was dropped to 18 kV. The experiment was to adjust ±7.5 KV at 100 KV output voltage. Figure 9 shows that the voltage was adjusted in a 7.5 KV range after the voltage was raised to 100 KV by introducing the voltage stabilizing link. Finally, the voltage stabilization was withdrawn to lower the power supply output to 0.

This experiment was carried out as a preceding test (to the computer control of the optimization of strongly ionized beams). Due to the serious environment, therefore, this exploratory experiment was conducted. Using the electrical insulating effect of optical fiber transmission of data, very satisfactory results were obtained from these experiments.

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