

CONTROL SIGNAL TRANSMISSION WITH OPTICAL FIBER

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ABSTRACT

Described is a new control signal transmission system which utilizes an optical fiber to transmit 2-bit control signals from the transmitter to receiver. In the transmitter the DC series control voltages are converted into the multiple frequency signals by voltage controlled oscillator (VCO). The multiple frequency signals can easily be transmitted by optical fiber. In the receiver the multiple frequency signals can be detected by analog or digital circuits and then be converted into 2-state control signals which can be used for a variety of applications.

1. INTRODUCTION

An optical fiber has been proposed to transmit video/audio signals in some transmission systems to take place of cable wires and electromagnetic waves. (1), (2) As has been known, an optical fiber has many excellent advantages such as wide bandwidth, low transmission loss, and no electromagnetic interference etc., so that we proposed a new transmission system in which series

control signals can be transmitted through an optical fiber.

In the transmitter a voltage controlled oscillator is used to generate multiple frequency signals corresponding to the DC series control voltages. Here the multiple frequency signals are used because firstly it can easily be transmitted through an optical fiber, secondly radio frequency interferences can be eliminated, and thirdly a greater number of control signals can easily be transmitted. The 2-bit series control signals have been sent in the experimental transmission system.

2. CONFIGURATION OF THE SYSTEM

Figure 1 shows the configuration of the control signal transmission system.

In the transmitter the multiple frequency signals are generated corresponding to the DC control voltages by using a voltage controlled oscillator (VCO). The timing and sequence of the series control signals can satisfactorily be adjusted by using the timing and sequence adjuster. The series multiple frequency signals are converted into optical pulses by electrical to optical (E-T-O) signal converter and then are fed to the receiver passing through an optical fiber.

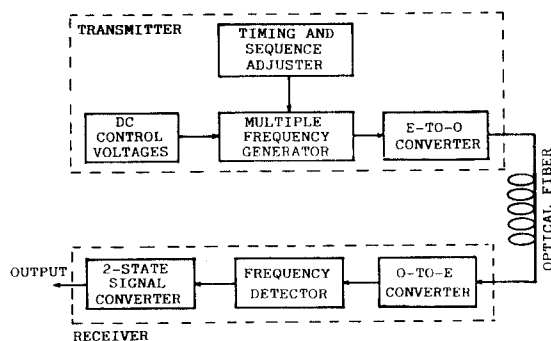


Fig.1 Block diagram of the system.

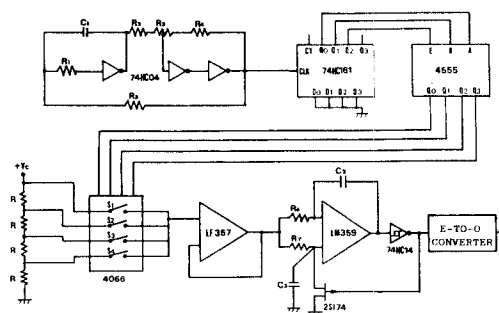


Fig.2 Circuit diagram of the transmitter.

Figure 2 shows the transmitter circuit diagram. A square-wave pulse with one second cycle time is generated by inverter 74HC04. The generated pulse is used as a clock signal of counter 74HC161 for controlling the switching time. The output of the counter is fed to decoder 4555 and the 4-state outputs of decoder 4555 are used as a control signal for analog switch 4066, so that DC control voltages can easily be adjusted with

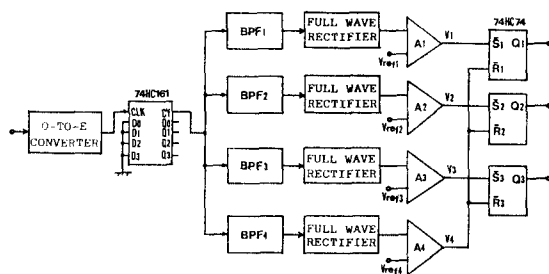


Fig.3 Configuration of the receiver (ANALOG).

Figure 3 shows the circuit configuration of the receiver consisting of analog circuits. The multiple frequency signals are reproduced from the received optical pulses by using an optical to electrical (O-TO-E) signal converter, and then divided by 1/16 with counter 74HC161 whose output is fed to bandpass filters. The center frequencies of the bandpass filters are specified respec-

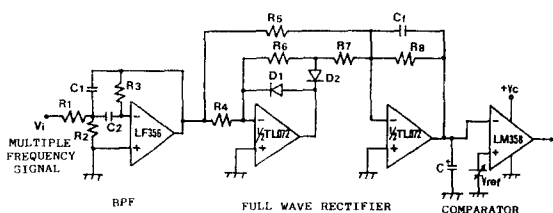


Fig.4 Circuit diagram of the bandpass filter and full-wave rectifier.

Figure 4 shows the bandpass filter (BPF) and full-wave rectifier circuits. An operational amplifier LM356 is used to build the bandpass filter whose center frequency has been set at corresponding to a control signal frequency. The BPF circuit parameters can be written as

$$\begin{aligned} C_1 &= C_2 = C \\ R_1 &= Q / (2 \pi f C G) \\ R_2 &= Q / (2 \pi f C (2Q^2 - G)) \\ R_3 &= Q / (\pi f C) \end{aligned}$$

where f is the BPF center frequency. The center frequency of each BPF is set at 80 kHz, 120 kHz, 150 kHz and 210 kHz, respectively. G is the BPF gain being set at 2. Q is the quality factor being set at 10.

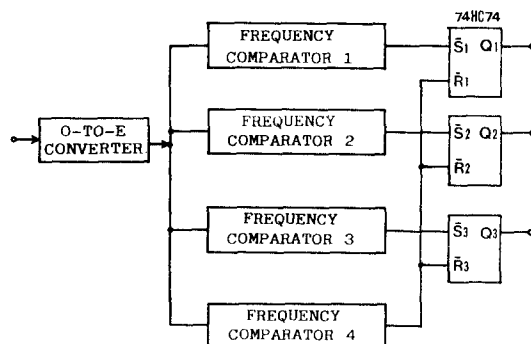


Fig.5 Configuration of the receiver (DIGITAL).

The output of the BPF is fed to the full-wave rectifier and comparator LM358 sequentially to convert the frequency signal into one bit of the 2-state control signals.

Figure 5 shows the circuit configuration of the receiver consisting of

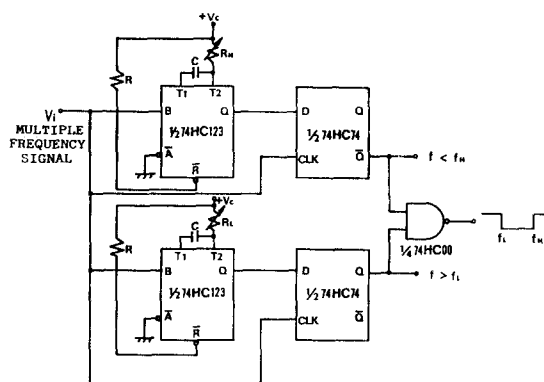


Fig.6 Circuit diagram of the frequency comparator.

digital circuits. The received optical pulse is fed to the optical to electrical (O-TO-E) signal converter to reproduce the multiple frequencies. The frequency comparators are used to detect the received frequencies and then convert them into corresponding 2-state control signals. The outputs of comparator 1, 2, and 3 are fed to the respective RS-type flip flops to set them. The output of comparator 4 is used as a reset signal of the RS-type flip flops.

Figure 6 shows the frequency comparator circuit. Multivibrators 74HC123 are used to specify frequencies f_H and f_L which are compared with the received signal frequency. The multivibrator at the top of Figure 6 generates f_H in terms of parameter $R_H C$. The multivibrator at the bottom of Figure 6 generates f_L in terms of parameter $R_L C$. After being compared with f_H and f_L , the received frequency signal makes the output of the circuit set at low level when the received signal frequency is greater than f_L and smaller than f_H , and the output of the circuit set at high level when the received signal frequency is greater than f_H or smaller than f_L .

3. PERFORMANCE OF THE SYSTEM

In the transmitter, the VCO is used to convert the series DC control voltages into the multiple frequencies. The relationship between the input and output of the VCO is shown in Figure 7 as an example. The output frequencies are 1.94, 1.25, 3.00 and 2.56 MHz corresponding to input DC voltages of 1.9, 1.1, 3.5 and 2.6 V, respectively.

Figure 8 shows the output signal waveform of the VCO which is set corresponding to an input DC control voltage of 3.5 V.

In the receiver, an operational amplifier LF356 is used to construct the bandpass filter, which makes the circuit configuration simple. The center frequen-

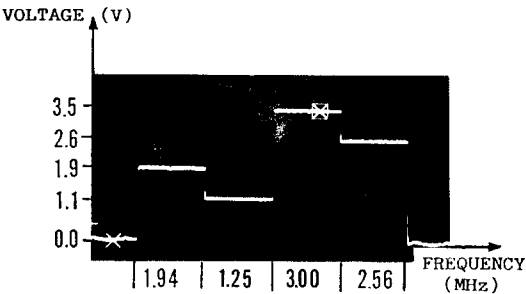


Fig.7 Relation between input and output of the VCO.

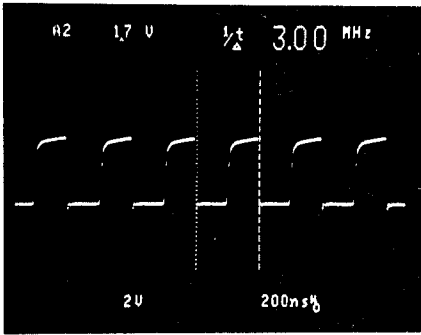


Fig.8 Output signal waveform of the VCO.

cies and 3 dB bandwidths of the bandpass filters are listed on Table 1. From Table 1, we know that the selectivity of the bandpass filter becomes inferior when the received frequency goes high. Therefore, the output of the bandpass filter is fed to the full-wave rectifier to convert it into a DC voltage level and then fed to

Table 1 Center frequencies and bandwidths of the BPF.

BPF	CENTER FREQUENCY(kHz)	3dB BANDWIDTH (kHz)
BPF1	80	72 - 86
BPF2	120	108 - 130
BPF3	160	145 - 175
BPF4	210	186 - 235

the comparator. Each of comparator reference voltage can be adjusted to obtain suitable detecting frequency bandwidth.

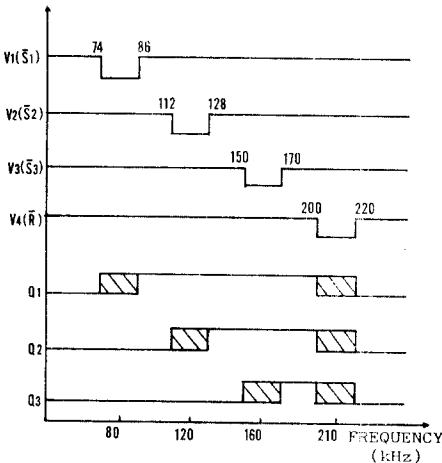


Fig.9 States of the flip flops corresponding to the received frequencies.

Figure 9 shows the output states of RS-type flip flops which are corresponding to the received frequencies. In our experiment, F/F_1 can be set at 80 kHz and be reset at 210 kHz. F/F_2 can be set at 120 kHz and be reset at 210 kHz. F/F_3 can be set at 160 kHz and be reset at 210 kHz.

Figure 10 shows the received control frequency signals (a), with the corresponding set/reset states of F/F_1 (b).

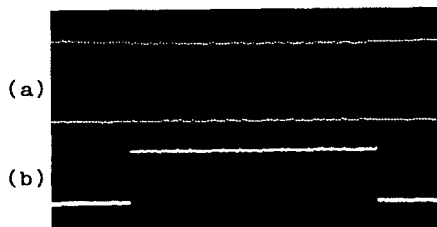


Fig.10 Received control signals and the corresponding output of F/F_1 .
(a) Frequency signal.
(b) F/F_1 output.

4. APPLICATION OF THE SYSTEM

Figure 11 shows an application of the system which has been described above. In Figure 11, an audio/data signal transmission system is illustrated. Here, the control signals are used as address signals. In the transmitter, the address signal generators are composed of a VCO. The address signals of 4 bits are produced from the multiple frequencies. After audio/data signal is mixed with address signals, they are transmitted to the carrier VCO. The carrier VCO is used to modulate these mixed signals. Using an E-TO-O converter the electrical signal is converted into an optical pulse with

an wavelength of 850 nm, and then the optical pulse passes through a multiple mode GI fiber. In the receiver, at first, the electrical signal can be reproduced by using O-TO-E converter and then the FM signal is demodulated by an edge detector with constant width pulse. The audio/data signal can be detected by low pass filter. The address signals can be detected by frequency detector and be converted into 2-state control signals. When the audio/data signal and address signal are fed to the multiplexer, the designated application can be accomplished.

5. CONCLUSION

control signals have been transmitted with an optical fiber, and have been applied to an audio/data signal transmission system where the control signals are used as address signals. When these multiple frequency signals are mixed and transmitted through an optical fiber, the receiver specified by address can easily take the received audio/data signal. In this audio/data signal transmission system, the address signals are set at 4 bits. If the number of control bits is increased, greater amount of control information can be transmitted by optical fiber. The control signal transmission method is not only suitable for controlling the audio/data signal transmitted but also suitable for a variety of industrial uses to control machines or facilities operating under inferior peripheral conditions.

ACKNOWLEDGMENT

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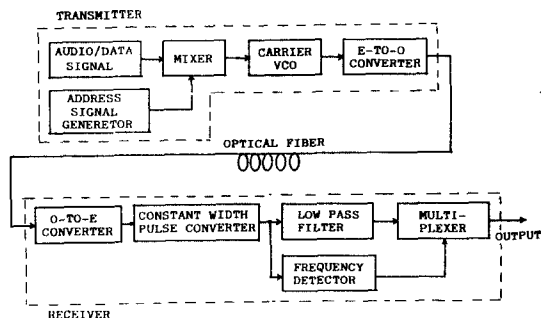


Fig.11 Configuration of the audio/data and address signal transmission system.