CONTROL SIGNAL DISTRIBUTION WITH OPTICAL FIBER

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ABSTRACT

Described is a new type of control signal transmission system in which an optical fiber is used in place of metal wire cables. This optical transmission system is reliable against EMI and also eliminates the frequency band limitation on the metal wire cables. Since the Z80 CPU is used to distribute the instructions, many tasks can be carried out very easily, and many errors can be avoided. Although an experiment was carried out for 4 bit binary data, the number of bits can be increased to 6 or more without any degradation in reliability. Thus, a variety of applications can be expected to be actualized with this control signal transmission system.

1.INTRODUCTION

In a conventional metal wire cable transmission system, signal quality degradation is usually caused by inferior EMI susceptibility of the transmission line. Since the EMI is serious when RF noise sources exist, it has to be avoided especially for use in industrial control signal transmission. In these cases, if an optical fiber is used in place of metal wire cables, the inferior EMI susceptibility of the transmission line can be eliminated.

In a telemetering or telephone system, frequency signals have been used to form an address(1). This kind of frequency signals can also be used as control signals if the optical fiber is used as the transmission line for the control signals.

The optical fiber can eliminate the frequency band limitation on the metal wire cables, the multiple frequency signals can be transmitted through the optical fiber at the same time. A variety of applications can be expected in transmitting control signals from one terminal to the other through the optical fiber(2)-(4).

A new concept of transmitting control signals from one terminal to the other via the optical fiber is described hereafter.

2.SYSTEM CONFIGURATION

Figure 1 shows the frequency domain used for the control signal transmission system actualized in the experiment. The control signals occupy 200 kHz, 300 kHz, 400 kHz and 500 kHz, and the carrier occupies 3 to 6 MHz, respectively. The carrier is used to modulate the control signals.

The square-wave frequency modulation (SWFM) can be accomplished by using the

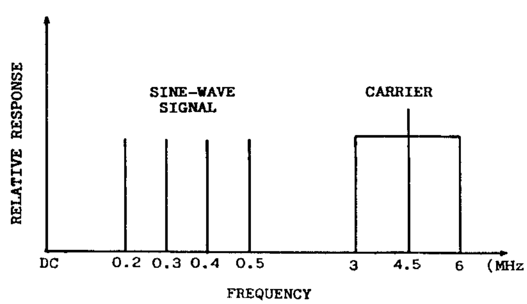

Fig.1 Frequency domain used for the control signal transmission.

carrier VCO, and then the SWFM signal is transmitted from the sender to the receiver terminal through the optical fiber as shown in Figure 2.

The control signal consists of multiple frequencies in the specified frequency domain. The control signal consisting of multiple frequencies can easily be generated by using a set of sine-wave generators, and it can easily be detected by using a set of bandpass filters to pass the designated frequencies through. The control signal consisting of multiple frequencies, each frequency indicating each bit of control signal, can be encoded by a key switching encoder and up to 2^n (n: number of frequencies) instructions can be specified by the operator.

The 4-bit sine-wave generator consists of a set of operational amplifiers to generate the sine-wave frequency signals at 200 kHz, 300 kHz, 400 kHz and 500 kHz indicating the input control signal bits.

The carrier VCO output is fed to an electronic-to-optical signal (E-TO-O) converter which consists of a pulse shaping circuit and an LED to emit the light pulse at 850 nm. The light pulse at 850 nm travels through the optical fiber, and then it is received by an optical-to-electronic signal (O-TO-E) converter in the receiver terminal. The optical-to-electronic signal converter consists of a PIN photo diode and a pulse amplifier.

The SWFM signal which is output from the optical-to-electronic signal converter is fed to an edge detector generating a fixed-width pulse, so as to convert the SWFM signal into the pulse FM signal whose frequency spectra contains the baseband of the input control signal.

The baseband of the control signal is reproduced by using a set of active bandpass filters to detect the multiple frequencies indicating the control signal, F/V converters to convert the frequency signals into the corresponding TTL levels, and then the Z80 CPU board to receive the control signal bits and to distribute the instructions to the loads in a specified sequence.

3.CONFIGURATION OF CONTROL SIGNAL ENCODER

Figure 3 shows the configuration of the control signal encoder. The sine-wave frequency signals at 200 kHz, 300 kHz, 400 kHz, and 500 kHz are generated from the respective sine-wave generators, each consisting of an operational amplifier. The sine-wave frequency signals at 200 kHz, 300 kHz, 400 kHz, and 500 kHz are used as bits 1 through 4 of 4-bit data. These sine-wave frequency signals are fed to a switching gate which converts binary control data into the encoded sine-wave frequency signals.

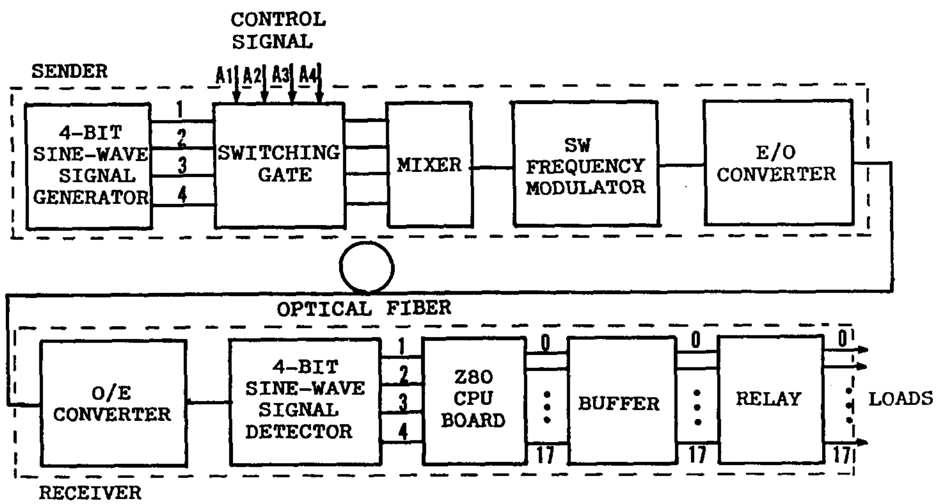

Fig.2 Configuration of the control signal transmission system.

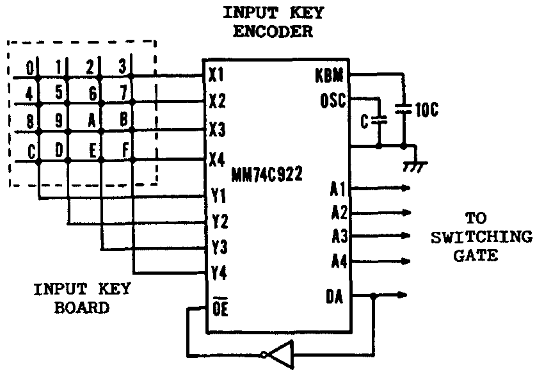

Fig.3 Configuration of the input control signal encoder.

The switching gate consists of a 16 key switch board, a key board encoder, and an analog switch. The 16 key switch board is employed for user to input control signal, then the input control signal is sensed by the key board encoder which coverts each input control signal into the corresponding state of the 4 bit binary digital signal. Then the 4 bit binary digital signal is used to control the switching gate to turn it ON or OFF, so as to encode the multiple frequency signal in accordance with the input control signal.

When the encoded frequency signals are mixed by using a mixer consisting of an operational amplifier, they are modulated by a carrier VCO used as a square wave frequency modulator. The SWFM signal is converted into the optical pulse signal by using the electronic-to-optical signal converter, then the optical signal passes through the optical fiber.

4. CONFIGURATION OF CONTROL SIGNAL DETECTOR AND DATA PROCESSOR

Figure 4 shows the configuration of the 4 bit control signal detector. The edge detector is used to convert the SWFM signal into the pulse FM signal. The baseband of the input control signals can be reproduced from the pulse FM signal by using a set of bandpass filters whose center frequencies are set at 200 kHz, 300 kHz, 400 kHz, and 500 kHz, respectively, so as to detect the multiple fre-

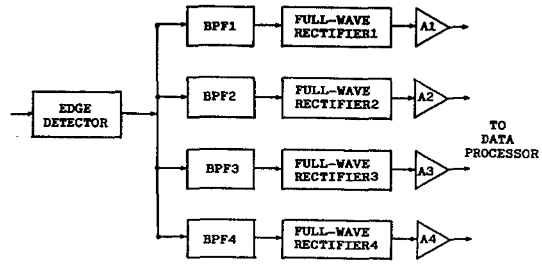

Fig.4 Configuration of the 4 bit control signal detector.

quency signals. The F/V converter consists of a set of full-wave rectifiers and comparators to reproduce the digital signal of 4 bits in accordance with the received frequency signal.

In order to issue the instructions in a serial sequence, and to avoid many errors which may occur when the control system is working, a Z80 CPU board is built in the receiver. The Z80 CPU is used to determine the schedule of the operations designated by operator, and to check the respective instructions coming from a user. Figure 5 shows the configuration of the Z80 CPU board which is one of the simplest 8 bit Z80 CPU's. A PIO 8255 is used as an input or output port for the Z80 CPU with the data bus, in which 4-bit data lines are used as input data lines, and the 16-bit data lines are used as output data lines. A EPROM 2764 is used to store the program for distributing instructions in a designated sequence, and it can be written or erased conveniently by the operator. A SRAM 6116 is used to store

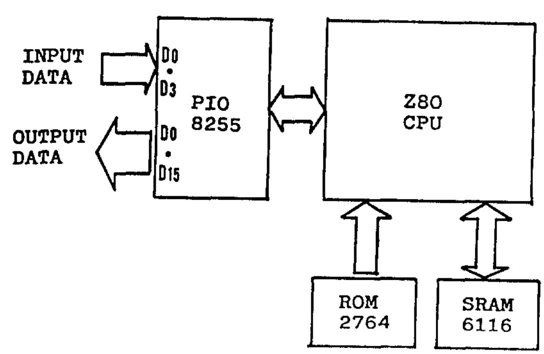

Fig.5 Configuration of the Z80 CPU data processor.

Table 1. States of binary data of 4 bits and the corresponding operation functions of allied loads.

Binary data	Function
0001	Reset.
1000	Put on lights.
1001	Put off lights.
0010	Start motor 1.
0011	Stop motor 1.
0100	Start motor 2.
0101	Stop motor 2.
1110	Put on heater.
1111	Put off heater.

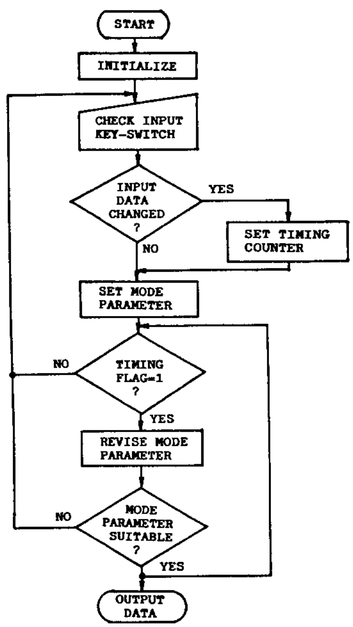

Fig.6 Flowchart of the operation of the Z80 data processor.

processing data when the program is operating, and the SRAM contains a battery back up circuit to keep processing data saving even when the external electrical power supply is cut in any cases.

Since 4 bit binary data can be decoded into 16 states in accordance with the input control signals, many systems can be controlled by using this 4 bit binary data, such as to start, stop, and select the operation mode et. al.. Table 1 lists an example of the states of binary data of 4 bits and the corresponding operation functions of allied loads.

Figure 6 shows the flowchart of the operation of the Z80 data processor.

5.CONCLUSION

Since the optical fiber is used as transmission line, the control signal transmission system presented heretofore is reliable against EMI.

Since the encoded multiple frequency signals can easily be transmitted by using the optical fiber, and also easily be detected by using a set of bandpass filters, it makes the configuration of the control signal transmission system very simple.

Since the Z80 CPU is used in the transmission system to process the input control signal in accordance with the designated program, many tasks can be carried out, and many errors can be avoided.

Although the experiment was carried out for binary data of 4 bits, the number of bits can be increased to 6 or more without any degradation in reliability. The variety of applications can be expected to be actualized with this control signal transmission system.

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