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(71) Applicants
Iwasaki Tsushinki Kabushiki Kaisha,
1-7-41, Kugayama,
Suginami-ku Tokyo-To,
Japan
(72) Inventors
Takashi Hirayama
Yuichi Igarashi
(74) Agents
Elkington and Fife,
High Holborn House,
52/54 High Holborn,
London WC2A 1AY

(54) Signal transmission system

(57) A signal transmission system which performs two-way signal transmitter-receiver and a second transmitter-receiver *via* a pair of signal lines (30) and supplies a DC current from the first to the second transmitter-receiver. The first and the second transmitter-receiver, are each provided with a current varying circuit for varying a signal line current by a transmission pulse signal so that the signal line current assumes a value in a predetermined current region which is below the minimum level of a load current delivered to the other transmitter-receiver during sending out of a signal pulse, a detector (13, 23, 23a) for detecting current or voltage variation in the signal line current, and a gate circuit (15, 27) for blocking the detected output from the current detector while the transmission pulse is being sent out via the current varying circuit.

Fig. 1

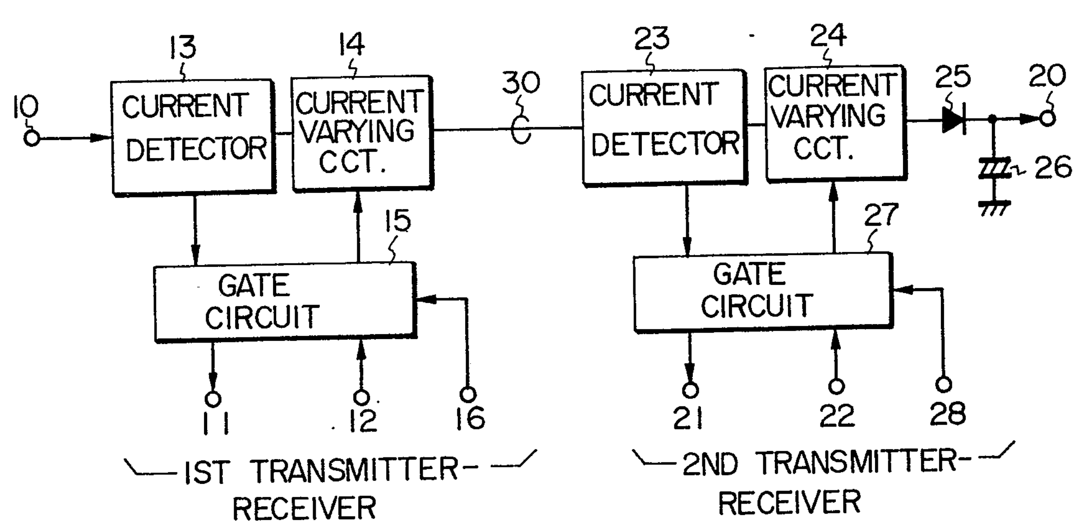

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Fig. 1

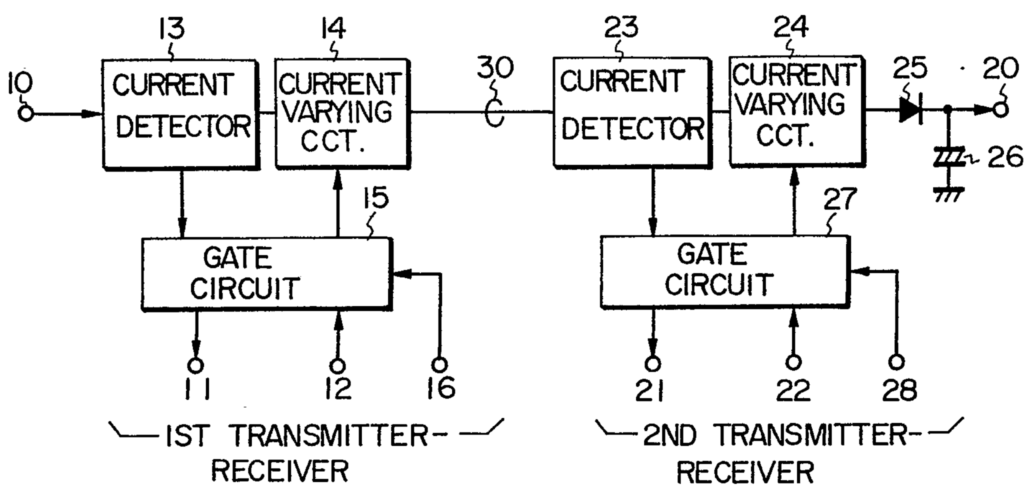

13
14
23
24
10
CURRENT DETECTOR
CURRENT VARYING CCT.
30
CURRENT DETECTOR
CURRENT VARYING CCT.
25
20
26
15
27
GATE CIRCUIT
GATE CIRCUIT
11
12
16
21
22
28
1ST TRANSMITTER-RECEIVER
2ND TRANSMITTER-RECEIVER

Fig. 2

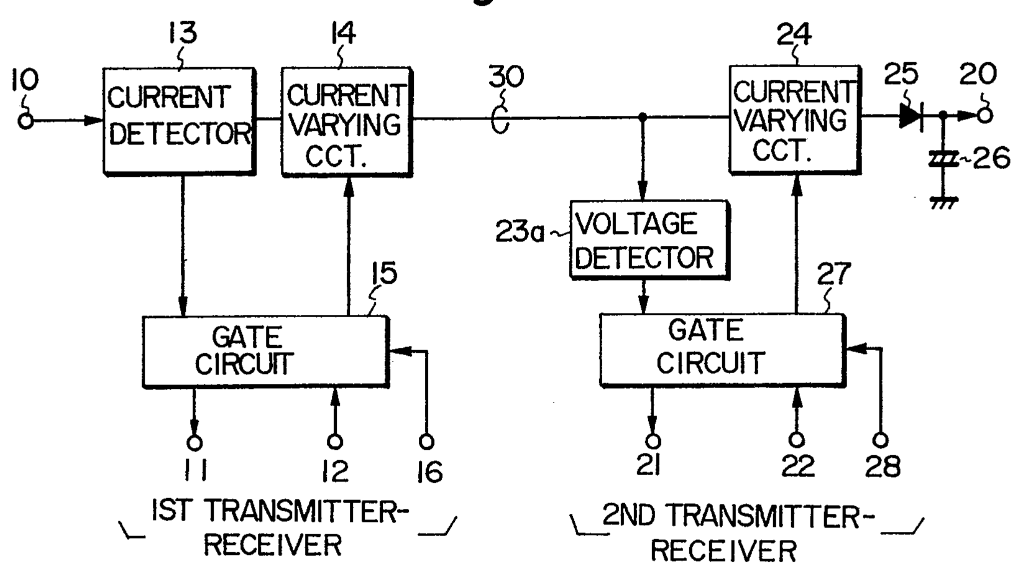

13
14
24
10
CURRENT DETECTOR
CURRENT VARYING CCT.
30
CURRENT VARYING CCT.
25
20
26
23a
VOLTAGE DETECTOR
15
27
GATE CIRCUIT
GATE CIRCUIT
11
12
16
21
22
28
1ST TRANSMITTER-RECEIVER
2ND TRANSMITTER-RECEIVER

Fig. 3

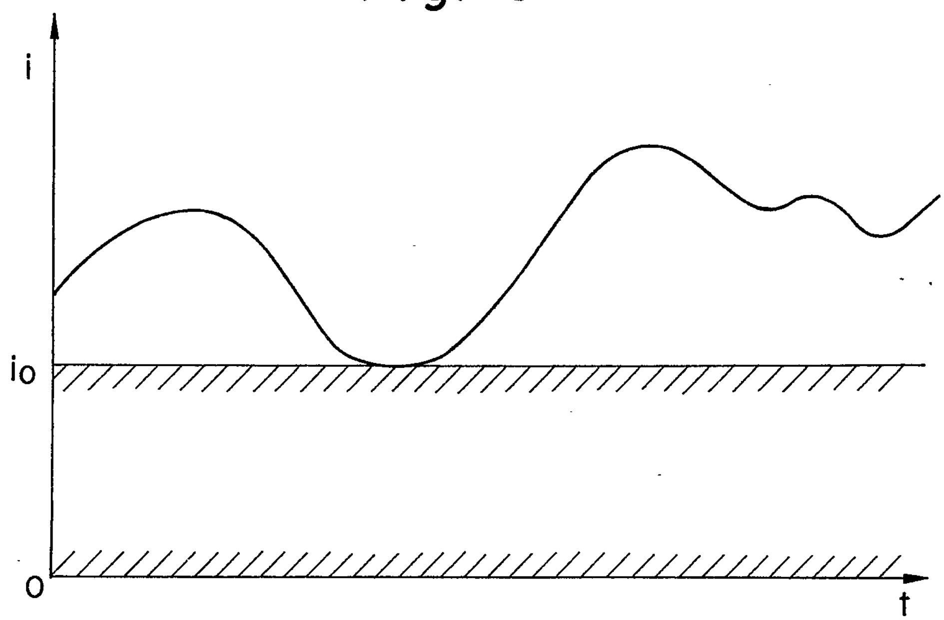


Fig. 4

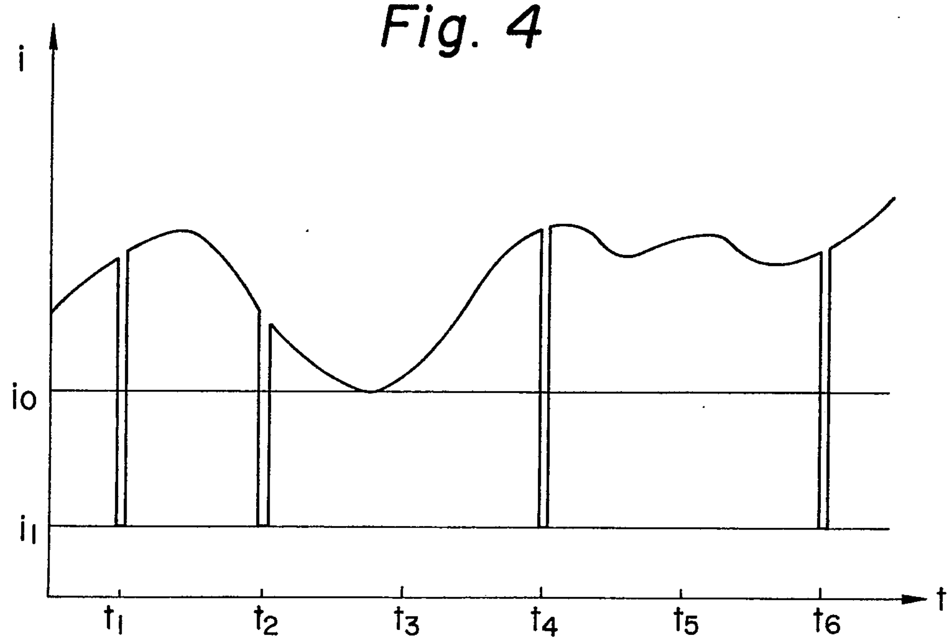
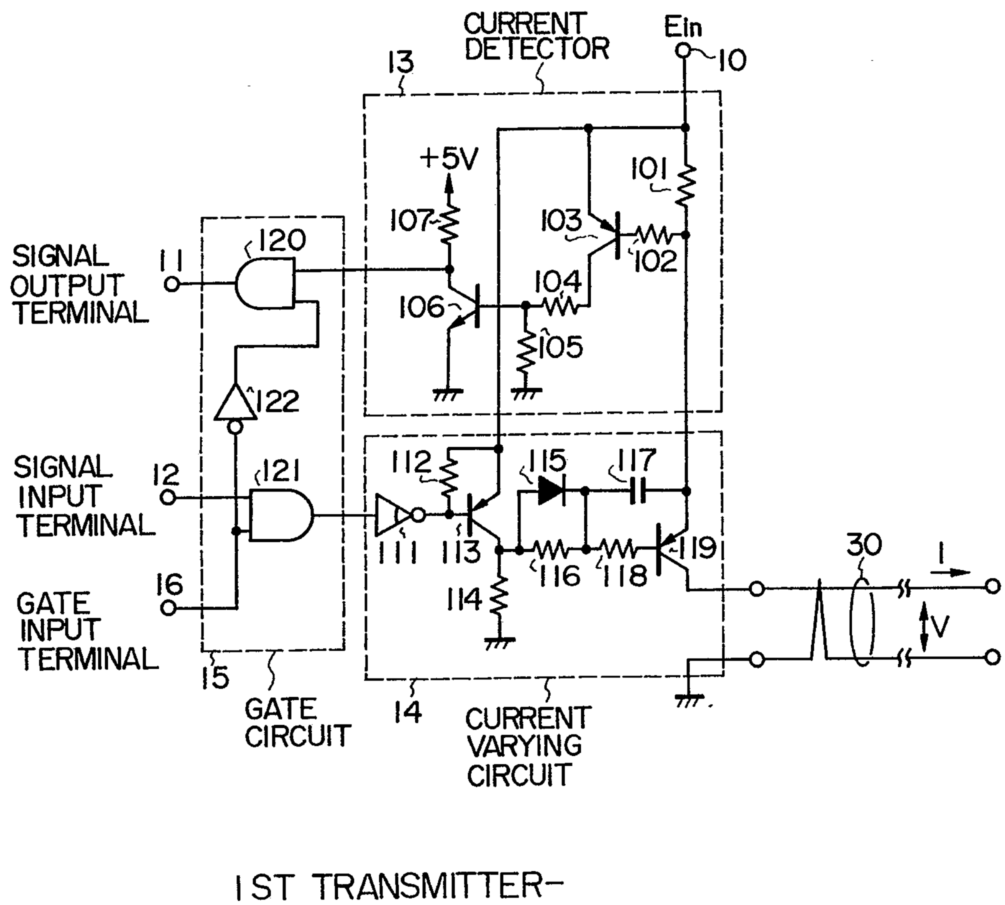
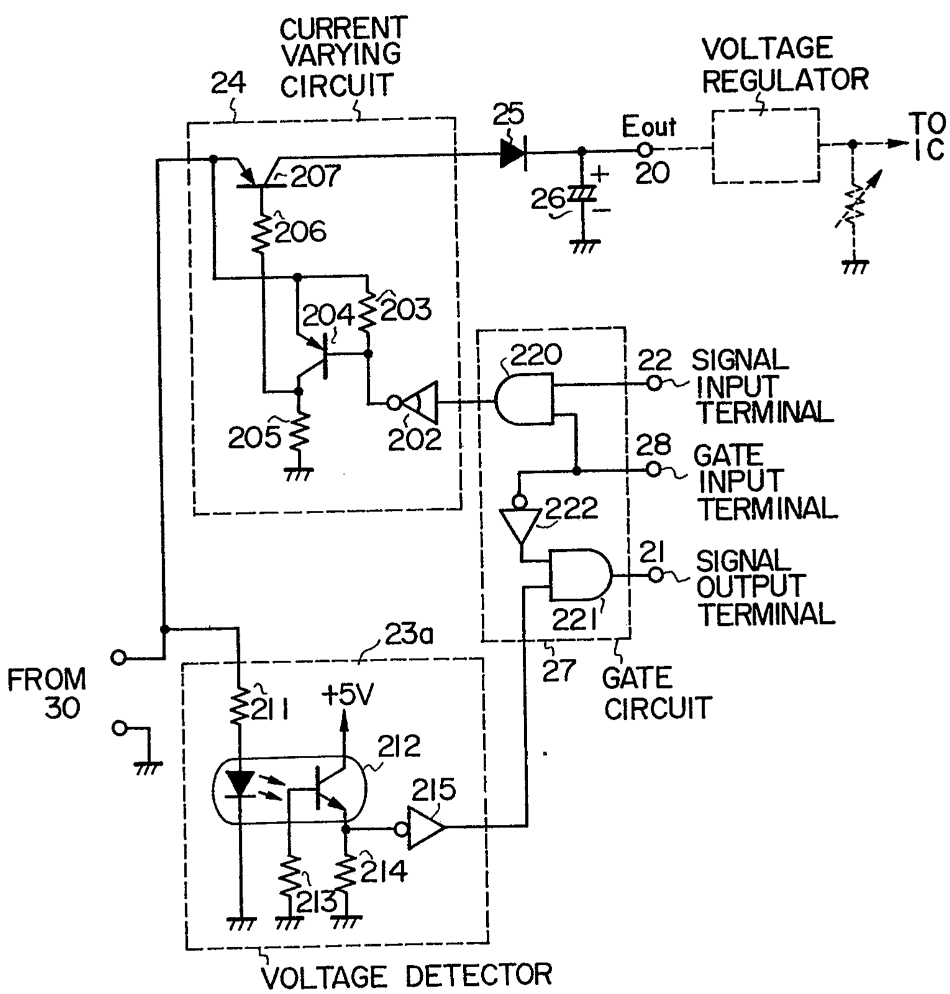


Fig.5A



1 ST TRANSMITTER-
RECEIVER

Fig. 5B



2ND TRANSMITTER-
RECEIVER

Fig. 6A

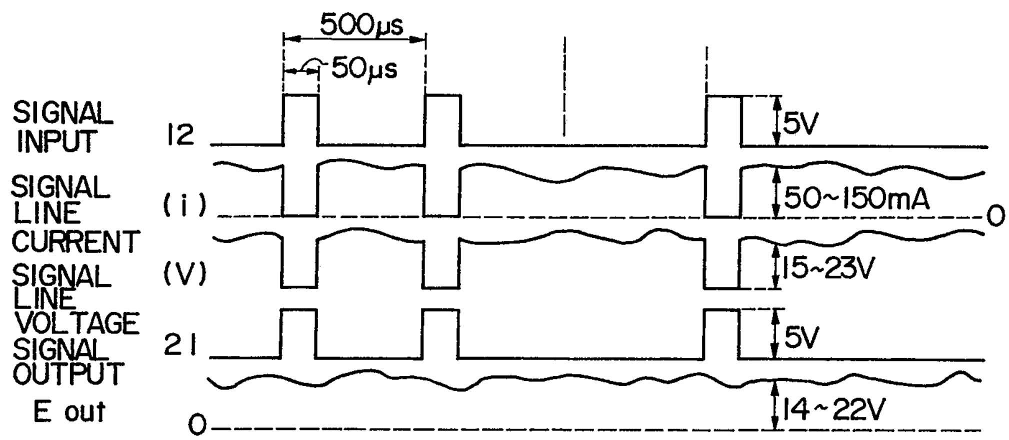

500μs
50μs
SIGNAL INPUT
12
5V
SIGNAL LINE CURRENT
(i)
50~150mA
0
SIGNAL LINE VOLTAGE
(V)
15~23V
SIGNAL OUTPUT
21
5V
E out
0
14~22V

Fig. 6B

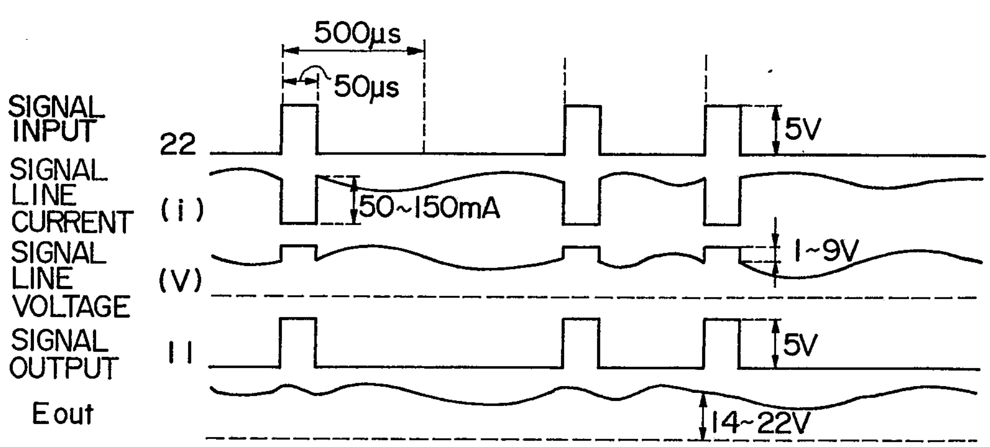

500μs
50μs
SIGNAL INPUT
22
5V
SIGNAL LINE CURRENT
(i)
50~150mA
SIGNAL LINE VOLTAGE
(V)
1~9V
SIGNAL OUTPUT
11
5V
Eout
14~22V

Fig. 7A

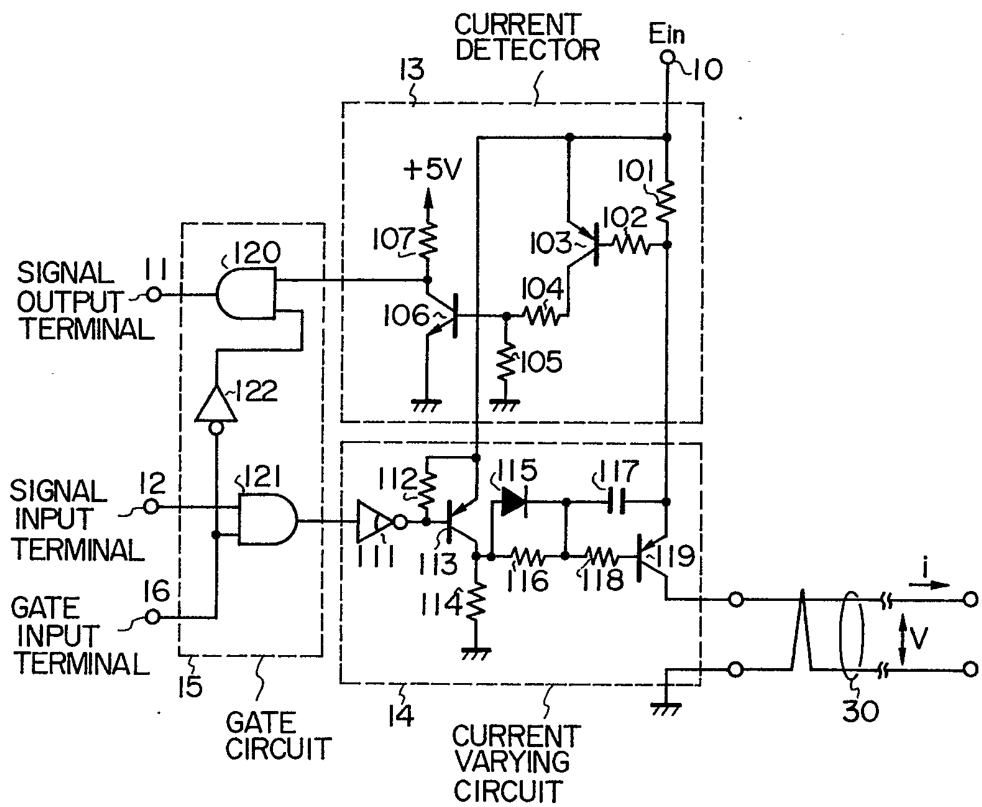

CURRENT
DETECTOR
Ein
10
13
+5V
101
102
103
107
120
SIGNAL
OUTPUT
TERMINAL
11
104
106
105
122
SIGNAL
INPUT
TERMINAL
12
121
112
115
117
111
113
116
118
119
114
i
V
GATE
INPUT
TERMINAL
16
15
GATE
CIRCUIT
14
CURRENT
VARYING
CIRCUIT
30

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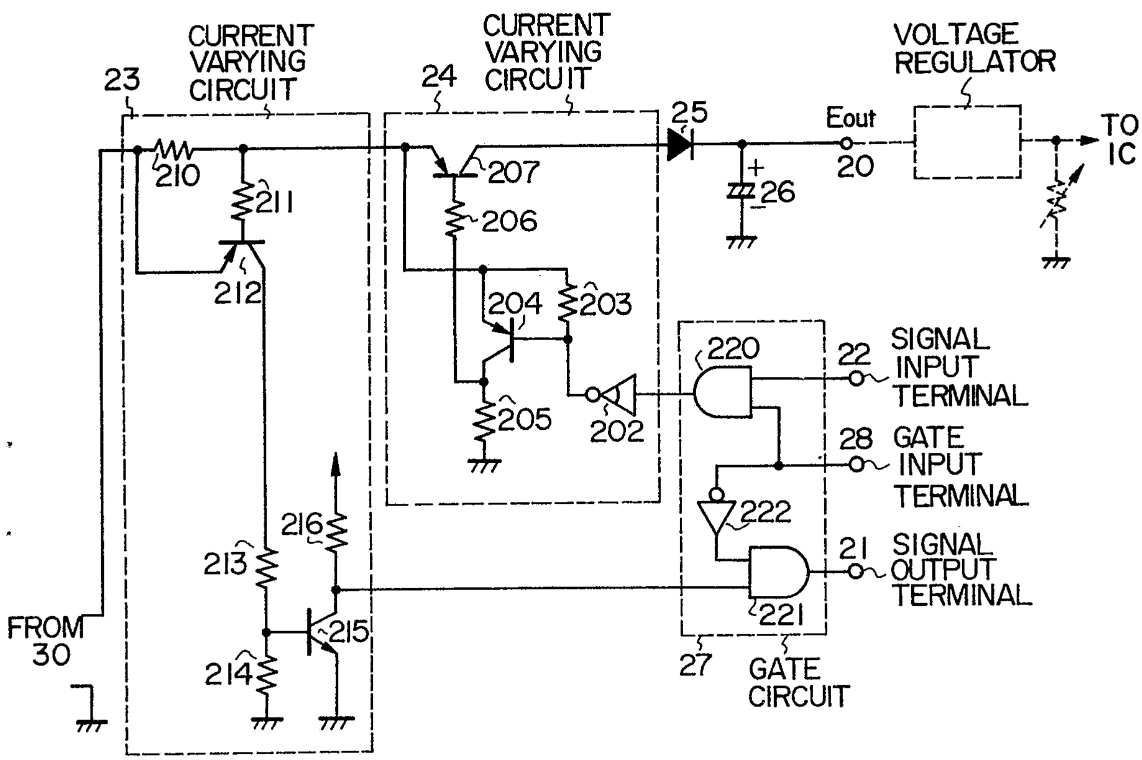
Fig. 7B



SPECIFICATION

Signal transmission system

The present invention relates to a signal transmission system which performs DC power supply and signal transmission and reception using a pair of signal lines.

In conventional systems of this kind in which signals are transmitted in two directions between first and second pieces of equipment *via* a pair of signal lines and a DC current is supplied from the first to the second piece of equipment, a constant-current circuit must be provided in the second piece of equipment in order that the first piece of equipment can make a distinction between a load fluctuation current and a signal current from the second piece of equipment. A fixed load and a signal current flow in the pair of signal lines, and a change in the signal current is detected as a signal by a current detector of the first piece of equipment. Accordingly, the constant-current circuit is required to be capable of consuming power since a difference in the load fluctuation current of the second equipment is multiplied by the DC input voltage of the second equipment, and this leads to a considerable power loss, resulting in an inefficient DC supply.

An object of the present invention is to provide a signal transmission system which permits signal transmission between two pieces of equipment by simple circuit arrangements *via* a pair of signal lines and highly efficient DC supply from one of the two pieces of equipment to the other, thereby to reduce the manufacturing costs and decrease the number of pairs of line pairs used in a cable.

According to the present invention, there is provided a signal transmission system which performs two-way signal transmission between a first transmitter-receiver and a second transmitter-receiver interconnected via a pair of signal lines and supplies a DC current from the first transmitter-receiver to the second transmitter-receiver. The first transmitter-receiver is provided with a first current varying circuit for varying a signal line current by a first transmission pulse signal so that the signal line current may assume a value in a predetermined current region below a minimum level of a load current to the second transmitter-receiver during sending out of a signal pulse from the first transmitter-receiver.

The second transmitter-receiver is provided with a second detector for detecting a current or voltage variation in the signal line current, a second current varying circuit for varying the signal line current by a second transmission pulse signal so that the signal line current may assume a value in the predetermined current region during sending out of the signal pulse, and a second gate circuit for blocking the detected output from the second detector while the second transmission pulse signal is sent out by the second current varying circuit. The first transmitter-receiver is further provided with a first current detector for detecting a current variation in the signal line current by the second transmission pulse, and a first gate circuit for blocking the detected output from the first current detector while the first transmission pulse signal is sent out.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Figs. 1 and 2 are block diagrams showing the principle of the signal transmission system of the present invention;

Fig. 3 is a waveform diagram explanatory of the principle of the signal transmission according to the present invention;

Fig. 4 is a waveform diagram explanatory of signal transmission operation according to the present invention;

Figs. 5A and 5B show a circuit diagram illustrating an embodiment of the present invention;

Figs. 6A and 6B are waveform diagrams explanatory of the operation of the embodiment shown in Figs. 5A and 5B;

and

Figs. 7A and 7B show a circuit diagram showing another embodiment of the present invention.

With reference to Fig. 1 a first operational principle will be described first. A first transmitter-receiver comprises a power source input terminal 10; a signal output terminal 11; signal input terminal 12; a first current detector; a first current varying circuit 14; gate circuit 15; and a first gate input terminal 16. A second transmitter-receiver comprises a power source output terminal 20; a signal output terminal 21; a signal input terminal 22; a second current detector 23; a second current varying circuit 24; a diode 25; a capacitor 26; a second gate circuit 27; and a gate input terminal 28. The first and second transmitter-receivers are interconnected *via* a pair of signal lines 30 indicated by a signal line.

Fig. 3 is a diagram showing the principle of signal transmission according to the present invention. Reference character *i* indicates a load current available from the power source output terminal 20; *t* designates time; and i_0 identifies a minimum level of the load current *i*. Let it be assumed that a predetermined, current region below the minimum level i_0, shown hatched in the Figure, is used for a signal.

Fig. 4 shows an operating waveform for the signal transmission. Reference character *i* indicates a current flowing in the pair of signal lines 30 and *t* designates time. Assuming that, from t_1 to t_6, pulses are sent out at regular intervals, if the signal is to be transmitted at the time slot, it is possible to take out the signal by detecting its presence or absence based on whether or not current changes to i_1 appear in a current region below the level i_0.

In Fig. 1, the gate circuit 15 is switched between transmission and reception modes by placing the gate input terminal 16 at a high-level and a low-level, respectively. When transmitting a signal from the first to the second transmitter-receiver, the gate input terminals 16 and 28 are usually rendered at the high-level and the low-level respectively, thereby establishing the current varying circuits 14 and 24 in states in which they permit the passage of current therethrough. When a signal is applied to the signal input terminal 12, the current varying circuit 14 is transferred to a state in which no current flows therethrough so that this current variation can be detected as a signal by the current detector 23. At that time, the power source output terminal 20 is disconnected from the current varying circuit 24 by the diode 25 but, by the capacitor 26, the power source output terminal 20 can be held at a certain voltage.

Next, in a case of transmitting a signal from the second to the first transmitter-receiver, the current varying circuits 14 and 24 are made to permit the passage of currents by placing the gate input terminals 28 and 16 at the high-level and low-level respectively, as is the case above. Upon application of a signal to the signal input terminal 22, the current varying circuit 24 is brought to a state in which current does not flow therethrough so that this current variation can be detected as a signal by the current detector 13. In this case, the power source output terminal 20 can be retained at a certain voltage, by the capacitor 26, permitting signal transmission and DC supply in the two directions.

In Fig. 2, the current detector 23 used in Fig. 1. is substituted by a voltage detector 23*a* to eliminate a voltage drop for current detection, and the illustrated circuit is otherwise identical in arrangement and in operation with that of Fig. 1.

Figs. 5A and 5B illustrate an embodiment of a signal transmission system of the present invention employing the operational principle described in connection with Fig. 2. As in Fig. 2 the first transmitter-receiver shown in Fig. 5A comprises the power source input terminal 10; signal output terminal 11; signal input terminal 12; current detector 13; current varying circuit 14; gate circuit 15 and the gate input terminal 16. The second transmitter-receiver shown in Fig. 5B, comprises the power source output terminal 20 which is connected *via* a voltage regulator to a load; signal output terminal 21; signal input terminal 22; voltage detector 23*a*; current varying circuit 24; diode 25; capacitor 26; gate circuit 27 (usually in the reception mode when held at low-level) 1 and the gate input 28.

For activating them, the gate input terminal 16 and the singal input terminal 12 are placed at the low-level and power is applied at the power source input terminal 10. The source power is supplied to the signal lines 30 via a resistor 101 and a transistor 119 in the ON state. Since the gate input terminal 28 is held at the low-level, a transistor 207 is in the ON state so that the signal lines 30 are connected to a load via the transistor 207, the diode 25, the capacitor 26, the power source output terminal 20 and the voltage regulator.

For transmitting a signal from the first to the second transmitter-receiver in the state mentioned above, the gate input terminal 16 is held at the high-level to switch the first transmitter-receiver to the transmission mode and positive pulses are applied to the signal input terminal 12. In this case, the transistor 119 is turned-OFF *via* an AND gate 121 of the gate circuit 15, an open-collector inverter 111 of the current varying circuit 14, a pull-up resistor 112, a transistor 113, a collector resistor 114, a diode 115 and a base resistor 118, inhibiting the passage of current through the transistor 119 As a result of this, a voltage drop occurs across the signal lines 30 to cut off the diode 25, resulting in no flow of load current. The voltage detector 23*a* of the second transmitter-receiver connected across the signal lines 30 assumes a state in which no current flows in a resistor 211 and a diode of photo-coupler 212 so that high-level pulses are obtained at the output side of an inverter 215 *via* a speed-up resistor 213 and an emitter resistor 214 of the photo-coupler 212. The resistor 114, the diode 115 and a capacitor 117 of the current varying circuit 14 of the first transmitter-receiver are used to delay only the rise of the current in the signal lines 30, preventing noise generation in other signal lines. The capacitor 26 is provided for maintaining a certain voltage across the load when the diode 25 is held at the OFF state.

For signal transmission from the second to the first transmitter-receiver, the gate input terminal 28 is held at the high-level to switch the second transmitter-receiver to the transmission mode and at the same time, the gate input terminal 16 of the first transmitter-receiver is held at the low-level to change it to the reception mode, in which an AND gate 120 is opened and the transmitter 119 assumes the ON state. Applying positive pulses to the signal input terminal 22 to the current varying circuit 24 of the second transmitter-receiver, the transistor 207 is turned-ON *via* an AND gate 220, an open-collector inverter 202, a pull-up resistor 203, a transistor 204, a collector resistor 205 and a base resistor 206, preventing the flow of the load current. This current variation is detected as a voltage drop (about 1 volt) across the resistor 101 of the current detector 13 of the first transmitter receiver by a base resistor 102 and a transistor 103, so that positive pulses are generated at the signal output terminal 11 via a collector resistor 104, a base resistor 105, a transistor 106, a collector resistor 107 and the AND gate 120. When the transistor 207 is held at the OFF state, charge stored in the capacitor 26 is discharged, by which the voltage across the load is held at a certain voltage.

As described above, the signal transmission between the first and second transmitter-receivers is possible, and since the transistors all perform the switching operations, no appreciable heat is generated and DC supply can be achieved at high efficiency. The larger the ratio of the period to the pulse width of the signal to be transmitted is, the more efficient is the DC supply.

Figs. 6A and 6B show signal waveforms transmitted in the embodiment of Fig. 5, Fig. 6A showing the signal waveform transmitted from the first to the second transmitter-receiver. In Fig. 5, the signal input 12 is at first held at the low-level and, when a positive pulse is applied to the signal input, a signal line current *i* of the signal line 30 (the line resistance of which is desired to be lower than 40 Ω) undergoes a negative pulse current variation in the case of a load current change of 50 to 150 m/. As a result of this, a signal line voltage V undergoes a negative pulse variation so that a positive pulse voltage waveform is generated at the signal output terminal 21 from the voltage detector 23*a*. A voltage E_{out} at the power source output terminal 20 is attenuated at a time constant corresponding to the load resistance (= E_{out}/load current) x the capacitance of the capacitor 26 upon each application of the signal.

Fig. 6B shows waveforms of signals which are transmitted from the second to the first transmitter-receiver. The signal input 22 is held at the low-level at first and when a positive pulse is applied thereto, a negative pulse current variation occurs in the signal line current *i*. Since the resistor 101 is connected in series with the signal line 30, a signal line voltage V is generated as shown and a positive pulse is provided at the signal output terminal 11 at the output side of the current detector 13. The voltage E_{out} at the power source output terminal 20 is the same as mentioned above.

Figs. 7A and 7B illustrate another embodiment of the signal transmission system of the present invention employing the operational principle described previously with respect to Fig. 1. This embodiment differs from the embodiment of Figs. 5A and 5B in the provision of the current detector 23, which comprises transistors 212 and 215 and resistors 210, 211, 213, 214 and 216. The resistor 210 is connected in series with the signal line 30 and, in the signal transmission from the first to the second transmitter-receiver, a current variation in the signal line 30 is detected by the base resistor 211 and the transistor 212, as a drop (about 1 volt) across the resistor 210 and positive pulses are provided at the signal output terminal 21 *via* the collector resistor 213, the base resistor 214, the transistor 215, the collector resistor 216 and an AND gate 221. The other operations of this embodiment are similar to those of the embodiments of Figs. 5A and 5B.

As has been described in the foregoing, the present invention permits the signal transmission and reception between two pieces of equipments through the use of a pair of signal lines and enables DC supply from one to the other; therefore, the present invention contributes to the reduction of the number of pairs of lines of a cable used and is of great utility from the economical view point. The present invention is applicable, for example, to a key telephone system and terminal I/O equipment of computers.

CLAIMS

1. A signal transmission system which performs two-way signal transmission between a first transmitter-receiver and a second transmitter-receiver interconnected *via* a pair of signal lines and supplies a DC current from the first to the second transmitter-receiver wherein the first transmitter-receiver is provided with a first current varying circuit for varying a signal line current by a first transmission pulse signal so that the signal line current assumes a value in a predetermined current region below a minimum level of load current to the second transmitter-receiver during sending out of a signal pulse from the first transmitter-receiver; the second transmitter-receiver is provided with a second detector for detecting a current or voltage variation in the signal line current, a second current varying circuit for varying the signal line current by a second transmission pulse signal so that the signal line current assumes a value in the predetermined current region during sending out of the signal pulse, and a second gate circuit for blocking the detected output from the second detector while the second transmission pulse signal is sent out by the second current varying circuit; the first transmitter-receiver is provided with a first current detector for detecting a current variation in the signal line current by the second transmission pulse, and a first gate circuit for blocking the detected output from the first current detector while the first transmission pulse signal is sent out.

2. A signal transmission system substantially as herein described with reference to Figure 1 or 2 with or without reference to any of Figures 3 to 7B of the accompanying drawings.

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