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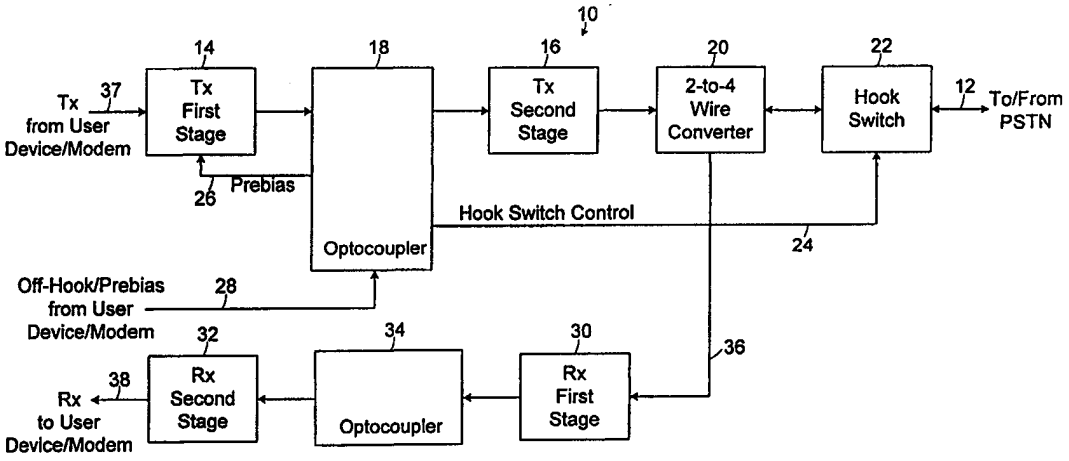

(57) Abstract

An isolation amplifier circuit with hook switch control (24) includes first (14) and second (32) amplifier stages optically isolated from and coupled to each other. A biasing circuit (26) is optically coupled to the amplifier to provide a switchable prebias to the amplifier to allow the amplifier to process bipolar voltage signals. A hook switch circuit (22) is coupled to the biasing circuit such that as the bias condition is switched, the hook switch is opened or closed. The same optical coupling circuitry (18) can be used to couple the first and second amplifier stages and to couple the biasing circuit to the hook switch circuit.

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ISOLATION AMPLIFIER WITH HOOK SWITCH CONTROL

Background of the Invention

Telephone interface devices such as modems and the like are typically used to couple a telephone line to a user device such as a computer. In general, these devices typically include a device interface for connection to the computer and a telephone line interface for connection to the telephone line. The telephone line interface typically includes a circuit of the type commonly referred to as a data access arrangement (DAA), which transmits and receives various telephone line signals and otherwise provides the standard required telephone line interface.

The circuitry in the interface device can include an isolation amplifier circuit which receives signals from the computer and couples them to the telephone line while providing the required isolation between the user device and the telephone line. The amplifier circuit can include first and second amplification stages optically isolated from and coupled to each other. In typical fashion, the first stage of the amplifier drives an optically emitting element such as a light-emitting diode (LED) which is optically coupled to a photosensitive element such as a photodiode in the second amplifier stage. A reflective dome is typically located over the LED and the photodiode to provide the optical coupling.

Typically, the signal coupled from the user device to the first amplifier stage is a bipolar signal, that is, its level swings between positive and negative voltages. To enable the isolation amplifier to accommodate the bipolar signal without clipping it, the interface device typically includes a prebiasing circuit which continuously applies a DC prebias voltage to the amplifier to raise the DC level of the amplifier such that the bipolar input signals can be processed.

Interface devices can also include switching circuitry, commonly referred to as a "hook switch", which closes a connection to the telephone line in an "off-hook" condition such that current is permitted to flow between the public switched telephone network (PSTN) and the user device. In the "on-hook" condition, the hook switch is open to

prevent current flow to the PSTN. A conventional hook switch circuit includes a relay controlled by the user device via a control signal which when activated closes the relay to make the connection with the telephone line and which when deactivated opens the relay.

In some prior systems, the hook switch control signal is optically isolated from the hook switch itself. The control signal activates an optical emitting device such as an LED which is optically coupled to a photosensitive device such as a phototransistor or photodiode. When the hook switch signal is activated, the photodiode is switched to an off-hook state to close the hook switch and thereby connect to the telephone line.

U.S. Patent number 5,555,293 to Krause describes an exemplary DAA telephone interface device illustrative of a typical prior art interface configuration. The DAA described in the '293 patent includes an isolation amplifier having optically coupled stages used to transfer signals between the telephone line and subscriber equipment. The device also includes a separate hook switch circuit driven by an off-hook control line. The off-hook control is optically coupled to the hook switch circuit which includes a pair of FET devices. The '293 patent is therefore illustrative of prior art systems which utilize individual and independent circuitry to provide line signal isolation/amplification and hook switch control.

Hence, prior art telephone interface devices, e.g., DAAs, can include a large amount of circuitry to implement and control the interface between the user device, e.g., modem, computer, and the telephone network. Such hardware-intensive systems can be quite expensive; therefore, reduction in the number of electronic components in such systems can be important in reducing overall size and cost.

Summary of the Invention

The present invention is directed to a interface circuit and method for providing an interface between a telephone line and a user telephone device such as a modem and/or a host computer. The circuit of the invention includes an isolation amplifier circuit which is coupled between the user telephone device and the telephone line and couples signals between the telephone device and the telephone line. A biasing means is coupled to the amplifier circuit to bias or "prebias" the amplifier circuit such that it can process bipolar variations in signals. The biasing means is switchable such that it can be switched between

a biased state in which a prebias is applied to the amplifier circuit and an unbiased state in which the prebias is not applied to the amplifier circuit. The interface circuit also includes a hook switch circuit which controls connection of the telephone device to the telephone line. The hook switch is switchable between a connected state in which current can flow between the telephone device and the telephone line and an unconnected state in which current flow is interrupted. The interface circuit also includes means for coupling the biasing means to the hook switch circuit such that as the biasing means is switched between the biased state and the unbiased state, the hook switch switches between the connected state and the unconnected state. Hence, the invention provides a telephone interface circuit in which control of the hook switch also controls application of a prebias to the amplifier and/or control of the amplifier prebias also controls the hook switch.

In one embodiment, the isolation amplifier circuit includes a first amplifier stage and a second amplifier stage optically coupled to each other to provide the required DC isolation between the telephone line and the user telephone device. The optical coupling device includes an optical emitting device, such as an LED, under a reflective element such as a reflective dome. As current flows through the LED, optical radiation is coupled by the reflective dome to a first photosensitive device, such as a phototransistor or photodiode, which is coupled to the first amplifier stage and a second photosensitive device coupled to the second amplifier stage. The current flow through the LED also applies the DC prebias to the amplifier to accommodate the bipolar nature of the signal being coupled to the telephone line. The current flowing through the LED is controlled by a control signal applied to a switch such as a transistor such that application of the prebias and coupling of the first and second amplifier stages can be externally controlled.

In one embodiment, the hook switch circuit includes an optically sensitive device such as a photodiode or phototransistor located in proximity to the same optically reflective element used to couple the first and second amplifier stages. When the prebias signal is activated to apply the prebias to the amplifier, optical radiation is also coupled from the LED to the photosensitive device of the hook switch circuit. The hook switch closes such that current flows in the telephone line. Hence, the control signal used to operate the prebias switch also operates the hook switch such that when the hook switch is closed to enter the off-hook state, the prebias is also applied to the amplifier circuit.

The interface circuit of the invention combines activation of the prebias and hook switch functions into a single operation. In one embodiment, this is accomplished by forming multiple optically coupled circuits under the same optically reflective dome. Specifically, in one embodiment, the optically sensitive devices for the first and second amplifier stages and the hook switch circuit and the LED are all formed under the same optically reflective dome.

The telephone interface circuit and method of the invention provide numerous advantages over prior approaches. For example, by combining the amplifier prebias and hook switch functions, the invention reduces circuit space and cost. A single optical isolation/coupling device is used to provide optical isolation/coupling for the amplifier stages as well as the hook switch control circuit. The use of a single optical coupling device where multiple devices were conventionally used saves circuit space and expense, which are extremely important in the competitive telecommunications hardware industry.

Also, the use of a switched prebias substantially reduces the overall power consumption of the interface circuit. The prebias is only applied and, therefore, consuming power when the interface is off-hook and in use. In prior systems, the prebias was applied continuously, resulting in constant wasted power.

Brief Description of the Drawings

The foregoing and other objects, features and advantages of the invention will be apparent from the more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings in which like reference characters refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

FIG. 1 is a schematic block diagram of one embodiment of the interface circuit of the invention.

FIG. 2 is a detailed schematic circuit diagram of the interface circuit of FIG. 1.

FIG. 3 is a schematic plot of amplifier output voltage versus time in the off-hook state with no transmit signal applied.

FIG. 4A is a schematic plot of an exemplary bipolar voltage signal as applied to the circuit of the invention.

FIG. 4B is a schematic plot of amplifier output voltage versus time in the off-hook state with the transmit signal of FIG. 4A applied to the amplifier.

FIG. 5 is a schematic plot of amplifier output voltage versus time for the on-hook state.

Detailed Description of the Preferred Embodiments

FIG. 1 is a schematic block diagram which illustrates one embodiment of the interface circuitry 10 of the invention. The circuitry 10 can perform functions of a DAA and therefore provide an interface between a user device such as a computer and/or modem and the public switched telephone network (PSTN), which is connected to the interface circuitry 10 by a telephone line 12. The circuitry 10 provides for a transmit (Tx) mode in which signals are transferred from the user device to the telephone line 12 and a receive (Rx) mode in which signals are transferred from the telephone line 12 to the user device.

The transmit isolation amplifier includes a first amplifier stage 14 and a second amplifier stage 16 which are optically isolated from and coupled to each other by an optical coupling circuit or optocoupler 18. A transmit signal from the user device is received at the first amplifier stage 14 on Tx line 37 and is amplified or otherwise processed by the first amplifier stage 14 and coupled by optocoupler 18 to the second amplifier stage 16. The amplified transmit signal from the second stage 16 is coupled to a hybrid interface circuit 20 which serves as a 2-to-4 wire converter and then through a hook switch 22 which, when closed by the hook switch control line 24, passes the transmit signal to telephone line 12.

The 2-to-4 wire converter 20 allows the circuitry 10 and user device to operate in a transmit/receive configuration using the standard 2-wire tip and ring telephone line 12. Each of the transmit and receive modes utilizes two wires and the 2-to-4 wire converter switches the two standard tip and ring telephone lines between transmit and receive circuitry depending on the operational mode of the interface.

The amplifier prebias is applied to the amplifier via the optocoupler 18 through line 26. When the Off-Hook/Prebias control signal on control line 28 is activated, the prebias is applied to the amplifier. In addition, activation of the Off-Hook/Prebias signal commands the interface circuitry 10 to an off-hook state via the hook switch control line

24. When the hook switch control line 24 is active, the hook switch 22 is closed such that current can flow in the telephone line 12 between the PSTN and the user device. Therefore, a single control line 28 is used to both apply the prebias to the isolation amplifier and control the hook condition of the interface circuitry 10 and, specifically, the hook switch 22. When the control line 28 is deactivated, the prebias is removed from the isolation amplifier circuit and the hook switch 22 is opened such that current is not permitted to flow to and from the telephone line 12.

The receive portion of the circuitry is similar to the transmit portion except for the prebias and hook switch control. The receive isolation amplifier includes a first amplifier stage 30 coupled to a second amplifier stage 32 by an optical coupling circuit or optocoupler 34. Signals from the PSTN are routed from the telephone line 12, through the hook switch 22 and 2-to-4 wire converter 20 along line 36 to the receive circuitry. The amplified received signal is transferred to the user device via line 38.

FIG. 2 is a more detailed schematic diagram of one embodiment of the interface circuitry 10 of the present invention. The isolation amplifier circuit of the invention can include resistors R1, R2, and R3, amplifiers 50 and 58 and the optical coupling circuitry 52, which can include an LED 53 and photosensitive transistors or photodiodes 55 and 56. The isolation amplifier is a unipolar photovoltaic amplifier. The input signal applied at the Tx terminal at line 37 is, in general, a bipolar sinusoidal waveform which crosses above and below ground. Because the amplifier is powered by a single-ended power supply V_{CC}, a prebias is applied to the amplifier to prevent clipping of the signal at ground. The output voltage V of the composite amplifier circuit on line 82, is given by:

$$V=(K3)(R3)\ [\frac{V_{CC}}{R2}+\frac{V_0 \sin\omega t}{R1}] \qquad (1)\ ;$$

where V_0 is the peak voltage applied to the input of the amplifier 50, and

$$K3=\frac{K2}{K1}\ ;$$

where K1 is the current transfer ratio of the LED 53 current to the photogenerated current developed by photodiode 55; and

K2 is the current transfer ratio of the LED 53 current to the photogenerated current developed by photodiode 56.

Since the input signal V_0 traverses above and below ground, and since a unipolar power supply V_{CC} is used, the prebias is applied to the amplifier such that the amplifier output V at line 82 is set to a DC quiescent output voltage V_Q at a level above ground and below V_{CC} such that the input signal on line 37 is not clipped by the single-ended amplifier 50. V_Q can typically be set to $V_{CC}/2$.

To illustrate, where no transmit signal is applied at the Tx terminal, that is, where $V_0 = 0$, and assuming that the overall transfer gain K3=1, then Equation 1 reduces to:

$$V=V_{CC}\,[\frac{R3}{R2}] \qquad (2).$$

So, for example, if $V_{CC} = 5$ volts and $V_Q = 2.5$ volts, then the ratio R3/R2 = ½. Choosing resistors R3 and R2 in accordance with the required ½ ratio will result in a quiescent output voltage V_Q at the desired level of 2.5 volts.

The quiescent output voltage V_Q is created by the current injected into the node 91 at the non-inverting node of amplifier 50, which causes an LED current I_f to flow. A resulting photocurrent I_1 of magnitude equal to that of I_f flows out of the node 91 such that the node 91 remains at virtual ground. Mathematically, $I_1 = (I_f)(K1)$. The LED 53 output light also impinges on photodiode 56 to cause a current I_2 to flow at the non-inverting node of the amplifier 58. This results in an output voltage $V=(I_2)(R3)$ at 82.

Hence, when the Off-Hook/Prebias signal is active (low), transistor 54 conducts current I_f such that LED 53 emits light. The light is reflected by a reflective dome at the optocoupler 52 to photodiodes 55 and 56 such that the amplifier stages 50 and 58 are coupled across optocoupler 52 to provide the output voltage V at line 82. With no signal applied at the Tx input, the prebias is applied such that only the DC quiescent voltage V_Q appears at line 82. However, when a transmit signal is applied, the output voltage V at line 82 is modulated as defined by Equation 1.

The output signal at 82 is coupled to circuitry 60 which serves the function of a 2-to-4 wire converter, which allows the transmit and receive functions of the circuit of the invention to be implemented in four lines connected through the 2-to-4 wire converter 60

to a standard 2-wire PSTN. The transmit signal is coupled via line 84 to a PNP Darlington transistor pair 62 which serves as the hook switch. When the Darlington pair 62 is activated via line 86 into saturation such that it conducts current, the output signal on line 84 is coupled through the diode bridge circuit 64 to the tip and ring lines of the telephone line 12.

As shown in FIG. 2, in one embodiment of the invention, the Darlington pair hook switch 62 is operated via a control line 86, the state of which is controlled by current through phototransistor 57 in the optical coupling circuit 52. The phototransistor 57 is located under the same reflective dome used for LED 53 and photodiodes 55 and 56 such that current through LED 53 is coupled to all three devices, 55, 56 and 57 at the same time. As described above, when the Off-Hook/Prebias signal is activated (low) and current I_f flows through LED 53, amplifier stages 50 and 58 are coupled together. In addition, phototransistor 57 is also simultaneously actuated such that the Darlington pair 62 conducts current, that is, the hook switch 62 is closed to allow current to flow through the telephone line 12. The circuit 66 is a gyrator circuit or electronic inductor which has a low DC resistance and high AC impedance to draw current from the telephone line.

The receive circuitry of the interface device 10 includes resistors R7 and R8, amplifiers 68 and 80, power supply circuit 78 and optical coupling circuitry 70 which includes an LED 72 and photodiodes 74 and 76 and an optically reflective dome. Input signals received on the tip and ring lines of the telephone line 12 are connected across the diode bridge 64 through the Darlington pair hook switch 62 to the 2-to-4 wire converter 60 via line 84. The circuitry 60 routes the incoming signal to the receive circuitry. The first stage of amplification provided by amplifier 68 drives the LED 72 which is powered through power supply circuitry 78. The circuitry 78 provides regulated power to the receive circuitry using the raw power from the telephone line 12. The modulated input signal is provided to the receive circuitry on line 81. The signal modulates the output of LED 72 via amplifier 68 and resistor R8. The input signal is coupled through the optical coupler 70 via the reflective dome to the photodiode 76 which transmits the signal to amplifier 80. The processed receive signal is coupled via line 38 to the user device or modem for processing.

FIGs. 3-5 contain voltage-versus-time plots which illustrate the various operating conditions of the interface circuit 10 of the invention. The plots assume that $V_{CC} = 5$ volts and that K3 = 1.

FIG. 3 is a plot of the voltage V at line 82 in the state in which no input transmit signal is applied at Tx, that is, where $V_0 = 0$. It also shows the situation where the interface circuit is in the off-hook condition. In this case, the output voltage V at line 82 is constant over time at $V = V_Q$, the quiescent DC output voltage.

FIG. 4A is a plot of an exemplary time varying signal applied at the Tx input. In general, the input signal is a bipolar voltage signal having an amplitude of V_0. That is, as shown in FIG. 4A, the signal voltage varies over time between positive (above 0 volts) and negative (below 0 volts) values.

FIG. 4B illustrates the situation in which the interface circuit of the invention is off-hook and the bipolar voltage signal of FIG. 4A having peak amplitude V_0 is applied at the Tx input. The voltage V at line 82 is a time-varying voltage signal which varies around a biased DC value of V_Q.

FIG.5 is a plot of the voltage V at line 82 in the state in which the system is on-hook, that is, where the Off-Hook/Prebias signal is in a deactivated (high) state such that no current I_f flows through LED 53. In this condition, the amplifier stages 50 and 58 are isolated from each other and no prebias is applied to the circuit. As a result, the signal V at line 82 is a constant level of 0 volts.

While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined in the following claims.

CLAIMS

1. An interface circuit for providing an interface between a telephone device and a telephone line comprising:

an amplifier circuit coupled between the telephone device and the telephone line for coupling a signal between the telephone device and the telephone line;

biasing means coupled to the amplifier circuit for biasing the amplifier circuit such that the amplifier circuit can process bipolar signals, the biasing means being switchable between a biased state and an unbiased state;

a hook switch circuit for controlling connection of the telephone device to the telephone line, the hook switch circuit being switchable between a connected state and an unconnected state; and

means for coupling the biasing means to the hook switch circuit such that as the biasing means is switched between the biased state and the unbiased state, the hook switch switches between the connected state and the unconnected state.

2. The interface circuit of claim 1 further comprising optical coupling means for optically coupling the biasing means to the hook switch circuit.

3. The interface circuit of claim 2 wherein the optical coupling means comprises an optically reflective element for reflecting optical radiation.

4. The interface circuit of claim 3 wherein the optical coupling means further comprises a plurality of photosensitive devices for receiving reflected optical radiation from the optically reflective element, one of said photosensitive devices being coupled to the hook switch circuit and another of said photosensitive devices being coupled to the amplifier circuit.

5. The interface circuit of claim 1 wherein the amplifier circuit comprises a first amplifier stage coupled to a second amplifier stage .

6. The interface circuit of claim 5 further comprising means for optically coupling the first amplifier stage to the second amplifier stage.

7. The interface circuit of claim 6 wherein the means for optically coupling the first amplifier stage to the second amplifier stage optically couples the biasing means to the hook switch circuit.

8. The interface circuit of claim 5 further comprising an optically reflective element for optically coupling the first amplifier stage to the second amplifier stage.

9. The interface circuit of claim 8 wherein the hook switch circuit comprises an optically sensitive device optically coupled to the optically reflective element to control switching of the hook switch circuit.

10. The interface circuit of claim 1 wherein the telephone device is a modem.

11. The interface circuit of claim 1 wherein the telephone device is a computer.

12. The interface circuit of claim 1 wherein the interface circuit is a data access arrangement (DAA).

13. An isolation amplifier comprising:

a first amplifier stage;

a second amplifier stage;

biasing means coupled to the amplifier circuit for biasing the amplifier circuit such that the amplifier circuit can process bipolar signals, the biasing means being switchable between a biased state and an unbiased state;

a switchable signal output circuit for providing a switchable signal output, the switchable signal output circuit being coupled to the biasing means such that as the biasing means is switched between the biased state and the unbiased state, the switchable signal output switches between a first state and a second state; and

optical coupling means for optically coupling the first amplifier stage to the second amplifier stage and optically coupling the biasing means to the switchable signal output circuit.

14. The isolation amplifier of claim 13 wherein the optical coupling means comprises:

an optically reflective element for reflecting optical radiation; and

a plurality of photosensitive devices for receiving reflected optical radiation from the optically reflective element, one of said photosensitive devices being coupled to the hook switch circuit and another of said photosensitive devices being coupled to one of the first and second amplifier stages.

15. The isolation amplifier of claim 13 wherein the isolation amplifier couples a telephone line to a telephone device and processes signals between the telephone line and the telephone device.

16. The isolation amplifier of claim 15 wherein the switchable signal output controls a hook switch which controls connection of the telephone device to the telephone line.

17. A method of providing an interface between a telephone device and a telephone line comprising:

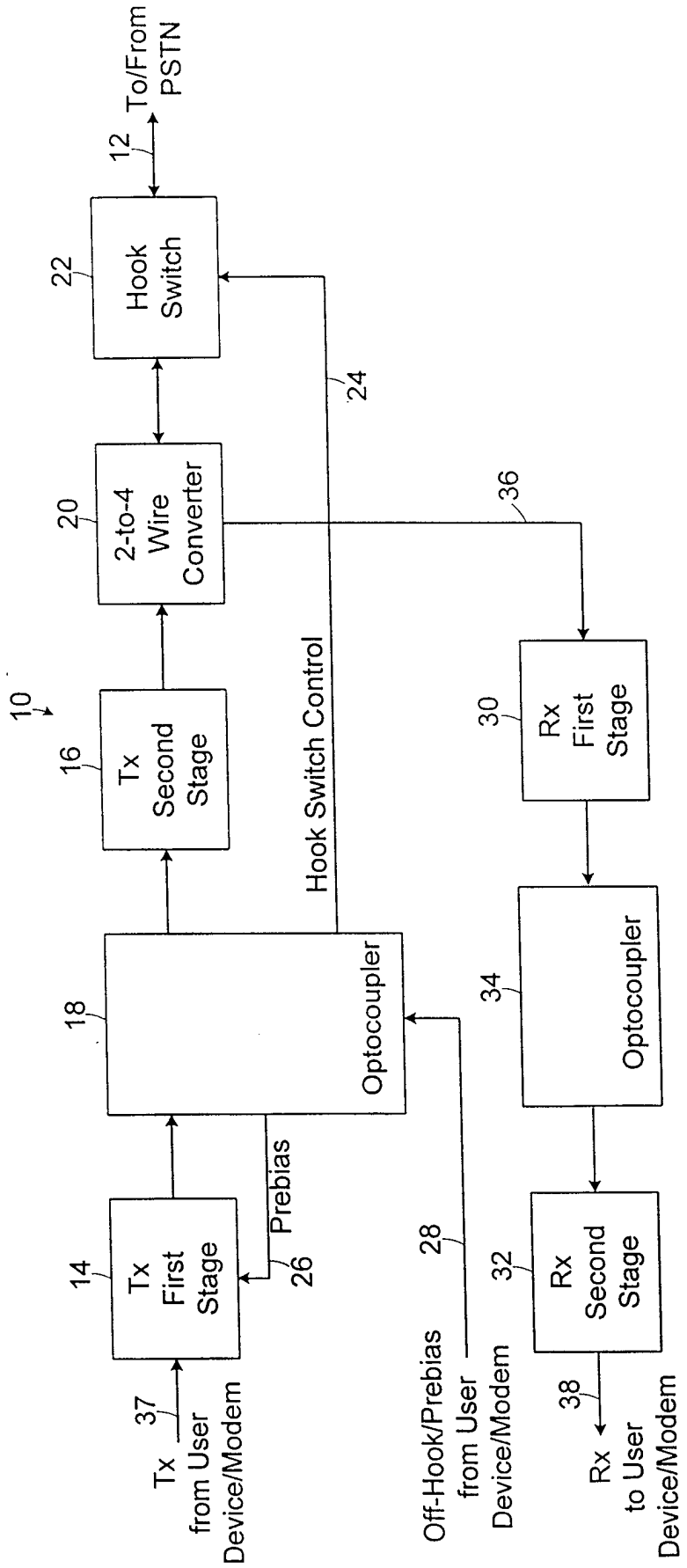
coupling an amplifier circuit between the telephone device and the telephone line to couple a signal between the telephone device and the telephone line;

coupling a biasing circuit to the amplifier circuit to bias the amplifier circuit to enable the amplifier circuit to process a bipolar signal, the biasing circuit being switchable between a biased state and an unbiased state;

providing a hook switch circuit for controlling connection of the telephone device to the telephone line, the hook switch circuit being switchable between a connected state and an unconnected state; and

coupling the biasing circuit to the hook switch circuit such that as the biasing circuit is switched between the biased state and the unbiased state, the hook switch circuit switches between the connected state and the unconnected state.

18. The method of claim 17 wherein the hook switch circuit is optically coupled to the biasing circuit.


10
12
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22
Hook Switch
24
20
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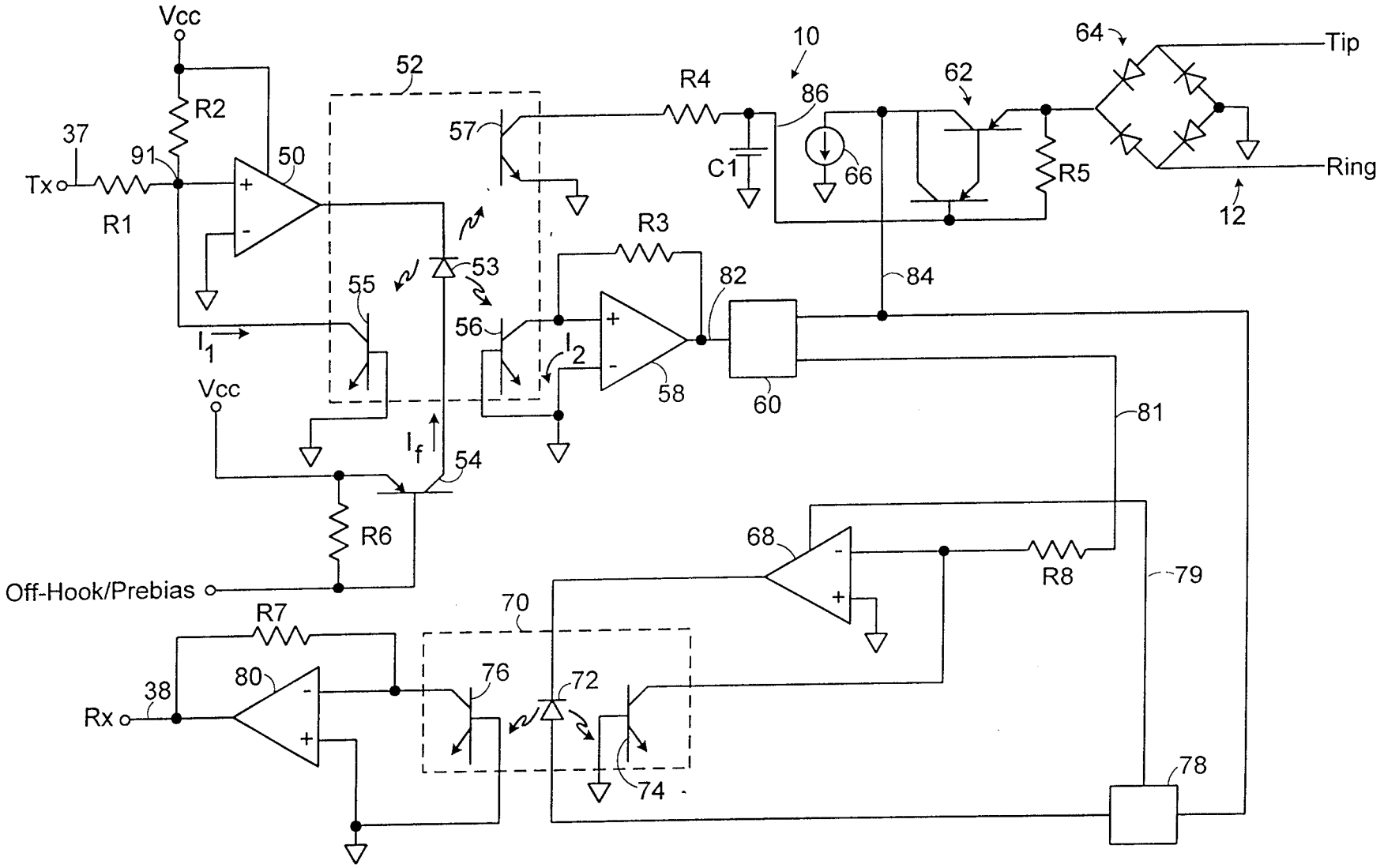
36
16
Tx Second Stage
Hook Switch Control
30
Rx First Stage
18
Optocoupler
34
Optocoupler
14
Tx First Stage
Prebias
26
28
32
Rx Second Stage
37
Tx from User Device/Modem
Off-Hook/Prebias from User Device/Modem
38
Rx to User Device/Modem

FIG. 1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Tx
R1
50
52
57
R4
10
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64
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C1
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12
R3
53
55
82
84
56
I_1
I_2
58
60
Vcc
81
I_f
54
R6
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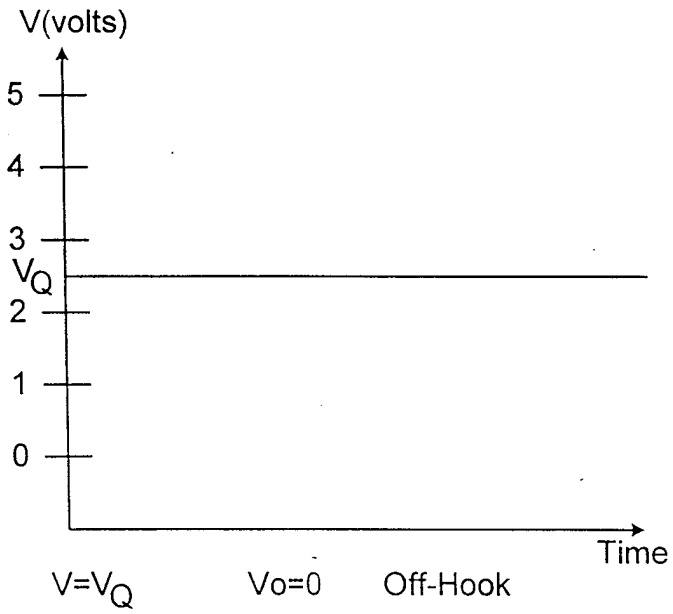
R8
79
Off-Hook/Prebias
70
R7
80
76
72
38
Rx
74
78

FIG. 2


V(volts)
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4
3
V_Q
2
1
0
Time
$V=V_Q$
Vo=0
Off-Hook

FIG. 3

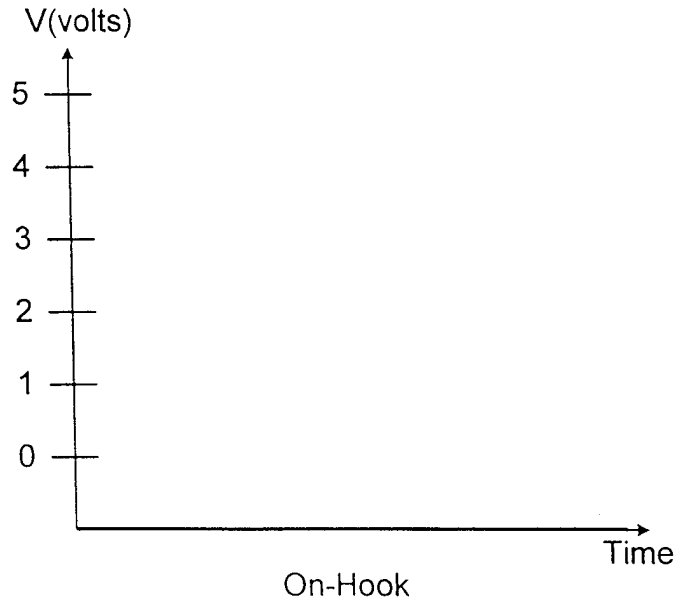
V(volts)
5
4
3
2
1
0
Time
On-Hook

FIG. 5

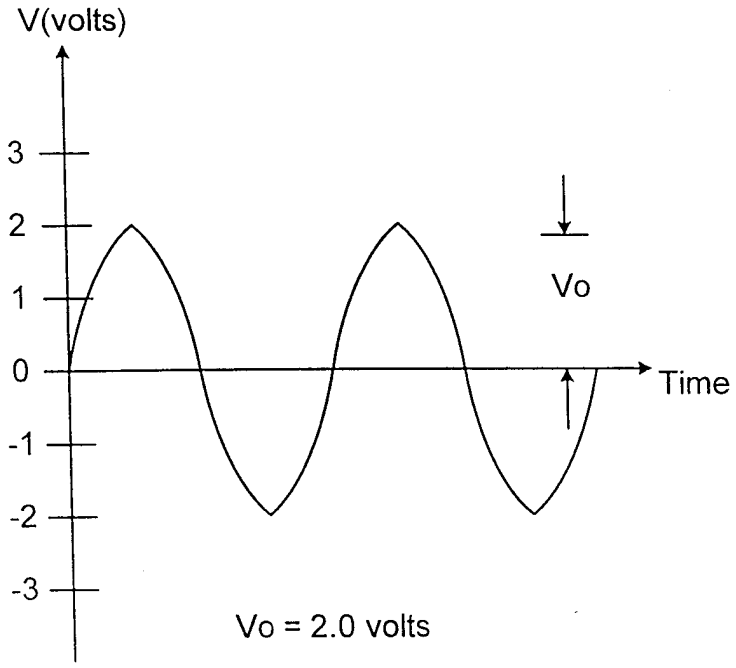
V(volts)
3
2
1
0
-1
-2
-3
Vo
Time
Vo = 2.0 volts

FIG. 4A

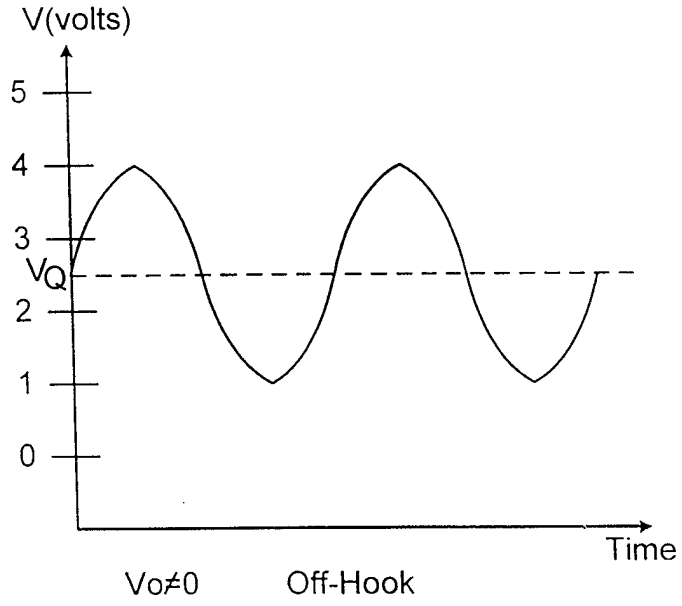
V(volts)
5
4
3
VQ
2
1
0
Time
Vo≠0
Off-Hook

FIG. 4B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/12269

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04M 1/00
US CL :379/399, 395; 330/136
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 379/399, 395; 330/136

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, MAYA
search terms: data access arrangement, line interface circuits, opto-isolators, opto-coupling, photo-coupling, isolation amplif?

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,282,604 A (JEFFERSON) 4 Aug. 1981, col.4, lines 1-68, col.5, lines 1-53	13-16
Y	US 5,555,293 A (KRAUSE) 10 Sep. 1996, FIG.1, col.3, lines 1-5, col.4, lines 51-52	1-12, 17-18
Y	US 5,242,654 A (WILKISON et al) 14 Sep. 1993, FIG.2A, FIG.2B, col.3, lines 21-68	13-18
Y	US 3,772,514 A (SUNDERLAND) 13 Nov. 1973, FIG.3, col.6 lines 2-35	13-18
A	US 4,742,538 A (SZLAM) 3 May 1988, abstract, col.6, lines 15-29	1-8
A	US 5,438,210 A (WORLEY) 1 Aug. 1995, FIG.4, col.4, lines 18-37, col.57-68	1-11

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/12269

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E,Y	US 5,774,541 A (KRAUSE), 30 Jun. 1998, FIG.1, col.2, lines 24-68, col.5, lines 3-64	1-18