

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
28 June 2001 (28.06.2001)

PCT

(10) International Publication Number
WO 01/47236 A2

(51) International Patent Classification⁷: **H04M 19/00**

(21) International Application Number: **PCT/IB00/01990**

(22) International Filing Date:
19 December 2000 (19.12.2000)

(25) Filing Language: **English**

(26) Publication Language: **English**

(30) Priority Data:
09/470,037 22 December 1999 (22.12.1999) **US**

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

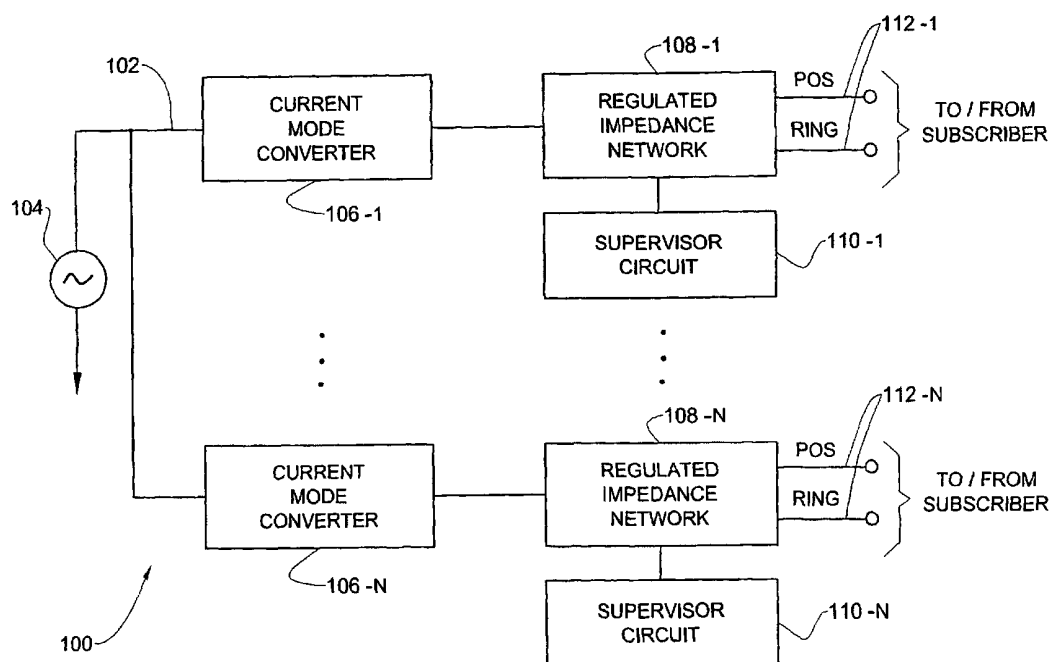
(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— Without international search report and to be republished upon receipt of that report.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: **REMOTE LINE FEEDING**



(57) Abstract: A line feeding circuit is provided. The line feeding circuit includes an input that is coupleable to an AC power supply. The line feeding circuit also includes at least one current mode converter, coupled to the input, that generates a DC current from the AC power supply. The line feeding circuit also includes at least two outputs, coupled to the current mode converter, that are coupleable to at least one subscriber line pair so as to provide DC current to the at least one subscriber line pair.



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Remote Line Feeding

Technical Field of the Invention

The present invention relates generally to the field of telecommunications
5 and, in particular, to remote line feeding in a telecommunications system.

Background

Telephone service is delivered to subscribers over a pair of wires known
conventionally as a twisted pair. The twisted pair is terminated on the subscriber
10 side by a telephone or other subscriber terminal. On the other side, the twisted pair
is terminated by a line card. The twisted pair carries information signals between the
subscriber terminal and the line card. The line card also provides power to the
telephone over the twisted pair for the telephone to operate.

Conventionally, the line card provides a standard DC current level to the
15 telephone, e.g., on the order of 20-50 milliamps (mA). This DC current is typically
provided from a high voltage DC power supply that is coupled to the twisted pair
through regulated circuits. Due to differences in telephone lines, e.g., distance,
resistance, and the like, the regulated circuits operate to dissipate power to reduce
the DC current provided at the subscriber terminals down to an acceptable level.
20 Unfortunately, this may result in significant power being dissipated and lost at the
line cards for some twisted pairs.

In some line cards, a DC regulator is provided to reduce the voltage on a per
line basis to reduce the power loss in the regulated circuits. However, since these
regulators are provided on a per line basis, this has proven to be a costly technique
25 for reducing power consumption.

For the reasons stated above, and for other reasons stated below which will
become apparent to those skilled in the art upon reading and understanding the
present specification, there is a need in the art for an improved mechanism for
providing DC current to a subscriber terminal over a twisted pair.

30

Summary

The above mentioned problems with providing DC current to telephone lines
5 and other problems are addressed by the present invention and will be understood by
reading and studying the following specification. A line feeding mechanism is
described which uses an AC power supply and a current mode converter to provide
DC current to the telephone lines with reduced power consumption over
conventional approaches.

10 In particular, an illustrative embodiment of the present invention includes a
line feeding circuit. The line feeding circuit includes an input that is coupleable to
an AC power supply. The line feeding circuit also includes at least one current
mode converter, coupled to the input, that generates a DC current from the AC
power supply. The line feeding circuit also includes at least two outputs, coupled to
15 the current mode converter, that are coupleable to at least one subscriber line pair so
as to provide DC current to the at least one subscriber line pair.

Brief Description of the Drawings

Figure 1 is a block diagram of an embodiment of a line feeding circuit
20 according to the teachings of the present invention.

Figure 2 is a block diagram of an embodiment of a current mode converter
for a line feeding circuit according to the teachings of the present invention.

Figure 3 is a block diagram of another embodiment of a current mode
converter for a line feeding circuit according to the teachings of the present
25 invention.

Figure 4 is a block diagram of another embodiment of a current mode
converter for a line feeding circuit according to the teachings of the present
invention.

Figure 5 is a block diagram of another embodiment of a current mode
30 converter for a line feeding circuit according to the teachings of the present
invention.

Figure 6 is a schematic diagram of an embodiment of an isolation circuit for a line feeding circuit according to the teachings of the present invention.

Figure 7 is a block diagram of another embodiment of a current mode converter for a line feeding circuit according to the teachings of the present invention.

Figure 8 is a block diagram of another embodiment of a line feeding circuit according to the teachings of the present invention.

Figure 9 is a block diagram of a portion of a communication system that incorporates subscriber line interface cards (SLICs) with line feeding circuits that use current mode conversion.

Detailed Description

The following detailed description refers to the accompanying drawings which form a part of the specification. The drawings show, and the detailed description describes, by way of illustration specific illustrative embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be used and logical, mechanical and electrical changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense.

Figure 1 is a block diagram of an embodiment of a line feeding circuit, indicated generally at 100, according to the teachings of the present invention. Circuit 100 provides DC current to a number of subscriber lines, conventionally referred to a "twisted pairs," using an AC source and a current mode converter. Advantageously, the arrangement of circuit 100 allows reduced power consumption by the line feeding circuit over conventional approaches which adjust the current provided to a particular line by controllably dissipating power from a DC source.

Circuit 100 includes input 102 that is coupled to AC source 104. AC source 104 comprises any appropriate source that generates alternating voltage. Input 102 is coupled to current mode converters 106-1, . . . , 106-N. In this embodiment, current mode converters 106-1, . . . , 106-N are coupled in parallel to AC source 104.

It is understood, however, that in other embodiments current mode converters are coupled in series from AC source 104.

For sake of clarity, circuit 100 of Figure 1 is described in terms of current mode converter 106-1 providing DC current to subscriber lines 112-1. However, it is understood that circuit 100 operates in a similar manner to provide DC current to the remaining subscriber lines.

Current mode converter 106-1 generates a DC current for at least one subscriber line pair 112-1 from the output of AC source 104. Embodiments of current mode converters are shown in Figures 2, 3, 4, 5, and 7 and are described in turn below. Advantageously, each of these current mode converters provides switching on and off with approximately zero current, so called "zero current switching," so as to provide reduced power dissipation over conventional solutions. In other embodiments, current mode converters use so called "zero voltage switching." The DC current from current mode converter 106 is provided to the at least one subscriber line pair 112-1, labeled "POS" and "RING" in Figure 1.

Supervisor circuit 110-1 provides control signals to regulated impedance network 108-1 to control transmission of signals over the at least one subscriber line pair 112-1. Regulated impedance network 108-1 is not controlled to dissipate power (current) to regulate the DC current provided on line 112-1. Rather, the current is controlled by current mode converter 106-1.

In operation, line feeding circuit 100 provides DC current to a plurality of subscriber line pairs 112-1, . . . , 112-N from common AC source 104. For example, circuit 100 provides a DC current to subscriber line pair 112-1 via current mode converter 106-1. Current mode converter 106-1 receives an input from AC source 104. Current mode converter 106-1 generates a DC current using the input from AC source 104. This DC current is provided to subscriber line pair 112-1.

Figure 2 is a block diagram of an embodiment of a current mode converter, indicated generally at 200, for a line feeding circuit according to the teachings of the present invention. Current mode converter 200 includes series resonant tank 202 coupled to rectifier 204. Series resonant tank 202 includes input 206 that is coupled to an AC source. In one embodiment, the resonant frequency of series resonant tank

202 is chosen to be at least twice the frequency of source 104. Rectifier 206 provides DC current at output 208 for a subscriber line pair.

In operation, current mode converter 200 receives an input from an AC source and provides a DC output current for at least one subscriber line. Series resonant tank 202 essentially acts as a pulse shaping network and converts the AC voltage received at input 206 to an AC current. Rectifier circuit 204 rectifies the signal from series resonant tank 202 such that the current is unidirectional, i.e., direct current. Thus, the combination of series resonant tank 202 and rectifier 204 provides a direct current at output 208 for at least one subscriber line pair.

Figure 3 is a block diagram of another embodiment of a current mode converter, indicated generally at 300, for a line feeding circuit according to the teachings of the present invention. Current mode converter 300 includes series resonant tank 302 coupled to rectifier 304.

Series resonant tank 302 acts as a pulse shaping network that generates an AC current using an AC voltage from the AC source. Series resonant tank 302 includes input 306 that is coupled to the AC source. Series resonant tank 302 also includes capacitor 310 and inductor 312. Capacitor 310 is coupled to input 306. Capacitor 310 is also coupled in series with inductor 312. Inductor 312 is also coupled to rectifier 304. In one embodiment, values for capacitor 310 and inductor 312 are chosen to set the resonant frequency of series resonant tank 302 to be at least twice the frequency of the AC source.

Rectifier 304 provides DC current at output 308 for a subscriber line pair. Rectifier 304 includes diodes 314 and 316. Diode 314 is coupled between series resonant tank 302 and the POS output of output 308. Diode 316 is coupled between series resonant tank 302 and the RING output of output 308. Diodes 314 and 316 have opposite polarities. Rectifier 304 also includes capacitor 318 coupled between the POS and RING outputs of output 308.

In operation, current mode converter 300 receives an input from an AC source and provides a DC output current for at least one subscriber line. Series resonant tank 302 essentially acts as a pulse shaping network and converts the AC voltage received at input 306 to an AC current. Rectifier circuit 304 rectifies the signal from series resonant tank 302 such that the current is unidirectional, i.e.,

direct current. Thus, the combination of series resonant tank 302 and rectifier 304 provides a direct current at output 308 for at least one subscriber line pair.

Figure 4 is a block diagram of another embodiment of a current mode converter, indicated generally at 400, for a line feeding circuit according to the teachings of the present invention. Current mode converter 400 includes series resonant tank 402 coupled to rectifier 404.

Series resonant tank 402 acts as a pulse shaping network that generates an AC current using an AC voltage from the AC source. Series resonant tank 402 includes input 406 that is coupled to the AC source. Series resonant tank 402 also includes capacitor 410 and inductor 412. Capacitor 410 is coupled to input 406. Capacitor 410 is also coupled in series with inductor 412. Inductor 412 is also coupled to rectifier 404. In one embodiment, values for capacitor 410 and inductor 412 are chosen to set the resonant frequency of series resonant tank 402 to be at least twice the frequency of the AC source.

Rectifier 404 provides DC current at output 408 for a subscriber line pair. Rectifier 404 includes diodes 414 and 416. Diode 414 is coupled between series resonant tank 402 and the POS output of output 408. Diode 416 is coupled between series resonant tank 402 and the RING output of output 408. Diodes 414 and 416 have opposite polarities. Rectifier 404 also includes capacitors 418 and 420. Capacitor 418 is coupled between the RING output of output 408 and ground. Further, capacitor 420 is coupled between the POS output of output 408 and ground.

In operation, current mode converter 400 receives an input from an AC source and provides a DC output current for at least one subscriber line. Series resonant tank 402 essentially acts as a pulse shaping network and converts the AC voltage received at input 406 to an AC current. Rectifier circuit 404 rectifies the signal from series resonant tank 402 such that the current is unidirectional, i.e., direct current. Thus, the combination of series resonant tank 402 and rectifier 404 provides a direct current at output 408 for at least one subscriber line pair.

Figure 5 is a block diagram of another embodiment of a current mode converter, indicated generally at 500, for a line feeding circuit according to the teachings of the present invention. Current mode converter 500 includes series resonant tank 502 coupled to rectifier 504.

Series resonant tank 502 acts as a pulse shaping network that generates an AC current using an AC voltage from the AC source. Series resonant tank 502 includes input 506 that is coupled to the AC source. Series resonant tank 502 also includes capacitor 510 and inductor 512. Capacitor 510 is coupled to input 506.

- 5 Capacitor 510 is also coupled in series with inductor 512. Inductor 512 is also coupled to rectifier 504. In one embodiment, values for capacitor 510 and inductor 512 are chosen to set the resonant frequency of series resonant tank 502 to be at least twice the frequency of the AC source.

Rectifier 504 provides DC current at output 508 for a subscriber line pair.

- 10 Rectifier 504 includes diodes 513, 514, 516 and 517. Diode 514 is coupled between an output of series resonant tank 502 and the POS output of output 508. Diode 516 is coupled between an output of series resonant tank 502 and the RING output of output 508. Diodes 514 and 516 have opposite polarities. Diode 513 is coupled between a node associated with the AC source and the POS output of output 508.
- 15 Diode 517 is coupled between the node associated with the AC source and the RING output of output 508. Diodes 513 and 517 have opposite polarities. Rectifier 504 also includes capacitor 518 coupled between the POS and RING outputs of output 508.

- In operation, current mode converter 500 receives an input from an AC
- 20 source and provides a DC output current for at least one subscriber line. Series resonant tank 502 essentially acts as a pulse shaping network and converts the AC voltage received at input 506 to an AC current. Rectifier circuit 504 rectifies the signal from series resonant tank 502 such that the current is unidirectional, i.e., direct current. Thus, the combination of series resonant tank 502 and rectifier 504
- 25 provides a direct current at output 508 for at least one subscriber line pair.

- Figure 6 is a schematic diagram of an embodiment of an isolation circuit, indicated generally at 600, for a line feeding circuit according to the teachings of the present invention. Isolation circuit 600 includes capacitor 604 and transformer 602. The AC source 606 is coupled to one plate of capacitor 604. The other plate of
- 30 capacitor 604 is coupled to an input of transformer 602. Transformer 602 provides output 608 to a subscriber line interface card (SLIC) that uses a current mode converter such as shown in figures 1 through 5 above.

In operation, isolation circuit 600 provides isolation between AC source 606 and a subscriber line interface card. The AC signals from AC source 606 are passed from one side of transformer 602 to output 608 for application to the subscriber line interface card. Transformer 602 provides isolation for the subscriber line interface card. For example, transformer 602 provides a floating DC current source with isolation from a common ground for a current mode converter and a subscriber line pair. This current mode converter also provides a symmetrical output at its outputs.

Further, transformer 602 provides reduced influence from unwanted electromagnetic fields and reduces the susceptibility of the current mode converter to noise. In one embodiment, transformer 602 includes a parasitic inductance that is used as an inductance for a series resonant tank of the current mode converter for the subscriber line interface card. In other embodiments, transformer 602 is used to scale the voltage provided by the AC source.

Figure 7 is a block diagram of another embodiment of a current mode converter, indicated generally at 700, for a line feeding circuit according to the teachings of the present invention. Current mode converter 700 includes series resonant tank 702 coupled to a plurality of rectifiers 704-1, . . . , 704-4. Advantageously, in this embodiment, the outputs of the plurality of rectifiers 704-1, . . . , 704-4 are coupled in series to allow a DC voltage output that is higher than the a battery voltage used by the AC source. It is noted that current mode converter 700 is not limited to an embodiment with four rectifiers. In other embodiments, current mode converter 700 includes more rectifiers with series coupled outputs and in other embodiments current mode converter 700 includes fewer rectifiers with series coupled outputs.

Series resonant tank 702 acts as a pulse shaping network that generates an AC current using an AC voltage from the AC source. Series resonant tank 702 includes input 706 that is coupled to the AC source. Series resonant tank 702 also includes capacitors 710-1, . . . , 710-4 and inductor 712. Inductor 712 is coupled to input 706. Inductor 712 is also coupled to one end of each of capacitors 710-1, . . . , 710-4. Capacitors 710-1, . . . , 710-4 are each coupled to a respective one of rectifiers 704-1, . . . , 704-4. In one embodiment, values for capacitors 710-1, . . . ,

710-4 and inductor 712 are chosen to set the resonant frequency of series resonant tank 702 to be at least twice the frequency of the AC source.

Rectifiers 704-1, . . . , 704-4 provide DC current at output 708 for at least one subscriber line pair. Rectifiers 704-1, . . . , 704-4 are each constructed in a similar
5 manner. Thus, for simplicity, only rectifier 704-1 is described in detail here.

Rectifier 704-1 includes diodes 714 and 716. Diode 714 is coupled between series resonant tank 702 and the POS output of output 708. Diode 716 is coupled between series resonant tank 702 and an output of rectifier 704-2. Diodes 714 and 716 have opposite polarities. Rectifier 704-1 also includes capacitor 718 coupled between the
10 POS output of output 708 and the output of rectifier 704-2.

In operation, current mode converter 700 receives an input from an AC source and provides a DC output current for at least one subscriber line. Series resonant tank 702 essentially acts as a pulse shaping network and converts the AC voltage received at input 706 to an AC current. Rectifier circuits 704-1, . . . , 704-4
15 each rectify the signal from series resonant tank 702 such that the current is unidirectional, i.e., direct current. Thus, the combination of series resonant tank 702 and rectifier 704 provides a direct current at output 708 for at least one subscriber line pair. Further, by connecting the outputs of rectifiers 704-1, . . . , 704-4 in series, the output voltage at output 708 is thus increased.

20 Figure 8 is a block diagram of another embodiment of a line feeding circuit, indicated generally at 800, according to the teachings of the present invention. Circuit 800 provides DC current to a number of subscriber lines, conventionally referred to a "twisted pairs," using an AC source and a current mode converter. Advantageously, the arrangement of circuit 800 allows reduced power consumption
25 by the line feeding circuit over conventional approaches which adjust the current provided to a particular line by controllably dissipating current from a DC source. Further, in this embodiment, the use of isolation in the current mode converter makes line feeding circuit 800 compatible with low voltage electronics of the supervisor circuit.

30 Circuit 800 includes input 802 that is coupled to AC source 804. AC source 804 comprises any appropriate source that generates alternating voltage. Input 802 is coupled to current mode converters 806-1, . . . , 806-N. In this embodiment,

current mode converters 806-1, . . . , 806-N are coupled in parallel to AC source 804. It is understood, however, that in other embodiments current mode converters are coupled in series from AC source 804 and share a common pulse shaping network.

For sake of clarity, circuit 800 of Figure 8 is described in terms of current mode converter 806-1 providing DC current to subscriber lines 812-1. However, it is understood that circuit 800 operates in a similar manner to provide DC current to the remaining subscriber lines.

Current mode converter 806-1 generates a DC current for at least one subscriber line pair 812-1 from the output of AC source 804. Embodiments of current mode converters are shown in Figures 2, 3, 4, 5, and 7 and are described above. Advantageously, each of these current mode converters provides switching on and off with approximately zero current, so called "zero current switching," so as to provide reduced power dissipation over conventional solutions. The DC current from current mode converter 806 is provided to the at least one subscriber line pair 812-1, labeled "POS" and "RING" in Figure 8.

Supervisor circuit 810 provides control signals to regulated impedance 808-1 to control transmission of signals over the at least one subscriber line pair 812-1. It is noted that in this embodiment, the same supervisor can be used to regulate a number of regulated impedances in line feeding circuit 800. Regulated impedance 808-1 is not controlled to dissipate power (current) to regulate the DC current provided on line 812-1. Rather, the current is controlled by current mode converter 806-1.

In this embodiment, current mode converters 806-1, . . . , 806-N use an isolation circuit such as shown in Figure 6. This allows the DC voltage on subscriber line pairs 812-1, . . . , 812-N to float. This makes the low voltage circuitry of supervisor circuit 810, e.g., analog to digital and digital to analog converters used to receive input and to provide control signals, compatible with the voltage on subscriber line pairs 812-1, . . . , 812-N.

In operation, line feeding circuit 800 provides DC current to a plurality of subscriber line pairs 812-1, . . . , 812-N from common AC source 804. For example, circuit 800 provides a DC current to subscriber line pair 812-1 via current mode converter 806-1. Current mode converter 806-1 receives an input from AC source

804. Current mode converter 806-1 generates a DC current using the input from AC source 804. This DC current is provided to subscriber line pair 812-1.

Figure 9 is a block diagram of a portion of a communication system, indicated at 900, that incorporates subscriber line interface cards (SLICs), 902-1, . . . , 5 902-N with line feeding circuits that use current mode conversion. In one embodiment, SLICs 902-1, . . . , 902-N are constructed as shown and described with respect to Figure 1. In another embodiment, SLICs 902-1, . . . , 902-N are constructed as described in Figure 8. SLICs 902-1, . . . , 902-N are coupled to switch 904 at a central office. Alternatively, SLICs 902-1, . . . , 902-N are located at a 10 remote unit and are coupled to switch 904 at the central office over some higher bandwidth connection, e.g., one or more T1 or E1 connections. Switch 904 is coupled to other switches in the public switched telephone network (PSTN) 906.

In operation, system 900 provides power to subscriber line pairs with reduced power consumption through the use of SLICs 902-1, . . . , 902-N with 15 current mode converters.

Conclusion

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific 20 embodiment shown. This application is intended to cover any adaptations or variations of the present invention. For example, other circuits that convert an AC source to a DC current can be used in place of the series resonant tank and the rectifier of the embodiments shown and described above.

What is claimed is:

1. A line feeding circuit, comprising:
 - an input that is coupleable to an AC power supply;
 - at least one current mode converter, coupled to the input, that generates a DC current from the AC power supply; and
 - at least two outputs, coupled to the current mode converter, that are coupleable to at least one subscriber line pair so as to provide DC current to the at least one subscriber line pair.
2. The line feeding circuit of claim 1, wherein the at least one current mode converter comprises:
 - a pulse shaping network, coupled to the input, that converts a voltage from the AC power supply to a current; and
 - a rectifier, coupled to the pulse shaping network, that provides a DC current for at least one subscriber line pair.
3. The line feeding circuit of claim 2, wherein the pulse shaping network comprises a series resonant tank.
4. The line feeding circuit of claim 2, wherein the pulse shaping network comprises an inductor coupled in series with a capacitor.
5. The line feeding circuit of claim 4, wherein the inductor comprises a parasitic inductance of a transformer.
6. The line feeding circuit of claim 4, wherein the rectifier comprises a pair of diodes and a capacitor.
7. The line feeding circuit of claim 4, wherein the rectifier comprises a plurality of rectification circuits coupled in parallel from a common pulse shaping network.

8. The line feeding circuit of claim 7, wherein the rectification circuits each include a capacitor coupled to a pair of diodes, wherein the capacitors of the rectification circuits are coupled in series.
9. The line feeding circuit of claim 1, and further comprising a supervisor circuit and at least one regulated impedance, the supervisor circuit coupled to regulate the impedance for transferring information on the at least one subscriber line pair.
10. The line feeding circuit of claim 1, and further comprising at least one transformer coupled between the input and the at least one current mode converter to provide isolation.
11. A system for feeding DC current to a plurality of telephony lines from an AC power supply, the system comprising:
 - at least one AC power supply; and
 - a plurality of current mode converters, coupled in parallel to the AC power supply such that each current mode converter provides a DC line current for at least one subscriber line pair.
12. The system of claim 11, wherein the current mode converter comprises:
 - a pulse shaping network, coupled to the AC power supply, that converts a voltage from the AC power supply to a current; and
 - a rectifier, coupled to the pulse shaping network, that provides a DC current for the at least one subscriber line pair.
13. The system of claim 12, wherein the pulse shaping network comprises a series resonant tank.
14. The system of claim 12, wherein the pulse shaping network comprises an inductor coupled in series with a capacitor.

15. The system of claim 14, wherein the inductor comprises a parasitic inductance of a transformer.
16. The system of claim 14, wherein the rectifier comprises a pair of diodes and a capacitor.
17. The system of claim 14, wherein the rectifier comprises a plurality of rectification circuits coupled in parallel from a common pulse shaping network.
18. The system of claim 17, wherein the rectification circuits each include a capacitor coupled to a pair of diodes, wherein the capacitors of the rectification circuits are coupled in series.
19. The system of claim 11, and further comprising a supervisor circuit and at least one regulated impedance, the supervisor circuit coupled to regulate the impedance for transferring information on the at least one subscriber line pair.
20. The system of claim 11, and further comprising a transformer for each current mode converter, each transformer coupled between the AC power source and one of the current mode converters to provide isolation.
21. A line feeding circuit comprising a current mode converter that provides dc current to at least one subscriber line from an AC source.
22. The line feeding circuit of claim 21, wherein the current mode converter is isolated from the AC source by a transformer.
23. The line feeding circuit of claim 21, wherein the current mode converter comprises a resonant tank and a rectifier.
24. The line feeding circuit of claim 21, wherein the current mode converter includes a transformer.

25. The line feeding circuit of claim 21, wherein the current mode converter is coupled to the AC source in parallel with other current mode converters for additional subscriber lines.
26. A method for providing DC current to a telephony line, the method comprising:
receiving an AC output from an AC power supply;
generating a DC current from the output of the AC power supply; and
providing the DC current over the telephony line.
27. The method of claim 26, and further comprising isolating the AC power supply with a transformer.
28. The method of claim 26, wherein receiving an AC voltage comprises receiving an AC voltage from one of a number of parallel outputs of the AC power supply.
29. The method of claim 26, wherein generating a DC current comprises generating the AC current with a series resonant tank and a rectifier.
30. A telephony system, the system comprising:
at least one switch; and
a plurality of line feeding circuits, coupled to the switch, each line feeding circuit comprising at least one current mode converter that provides dc current to at least one subscriber line from an AC source.
31. The system of claim 30, wherein the current mode converter is isolated from the AC source by a transformer.
32. The system of claim 30, wherein the current mode converter comprises a resonant tank and a rectifier.

33. The system of claim 30, wherein the current mode converter includes a transformer.

34. The system of claim 30, wherein the current mode converter is coupled to the AC source in one of parallel and series with other current mode converters for additional subscriber lines.

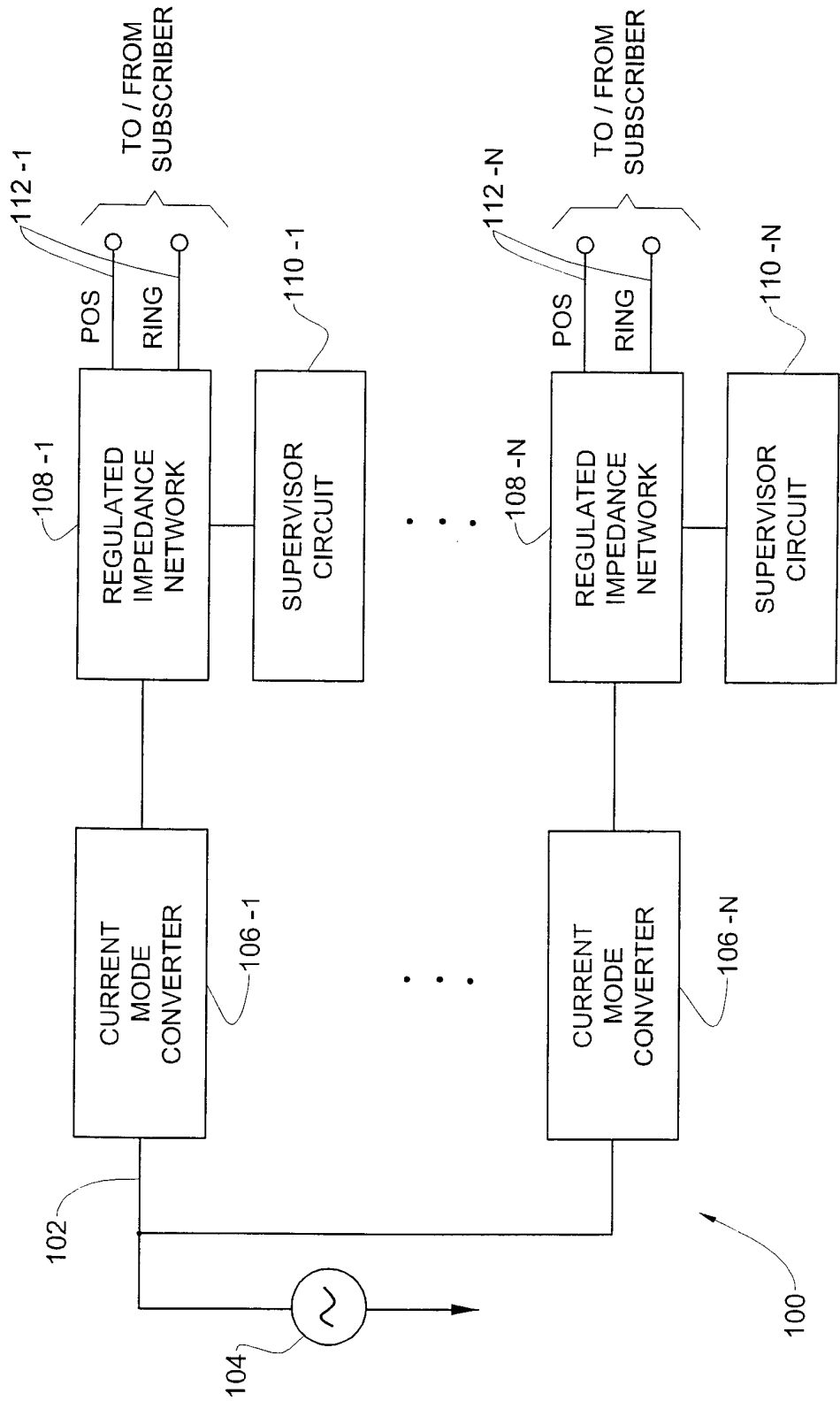


FIG. 1

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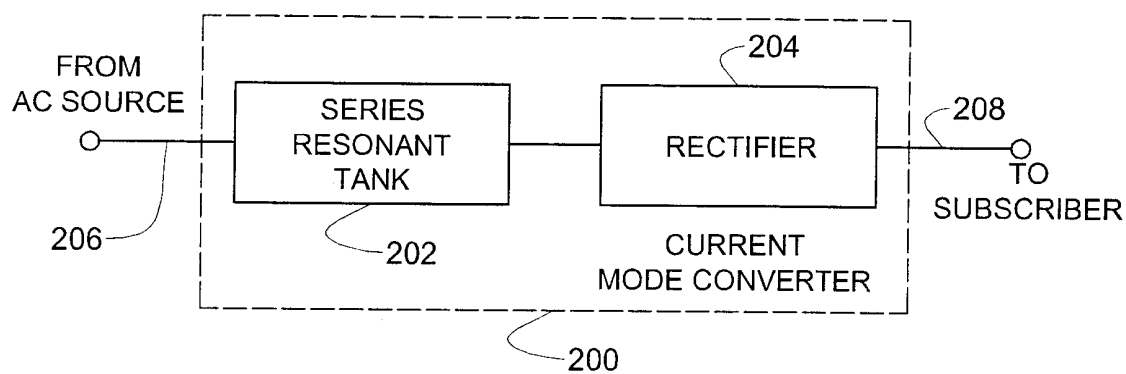


FIG. 2

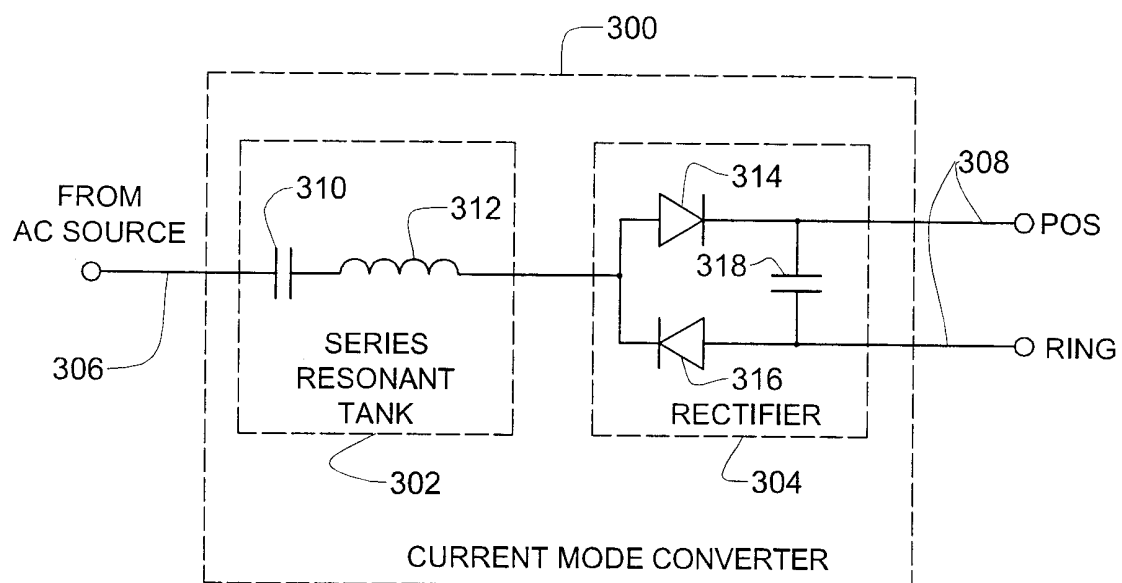


FIG. 3

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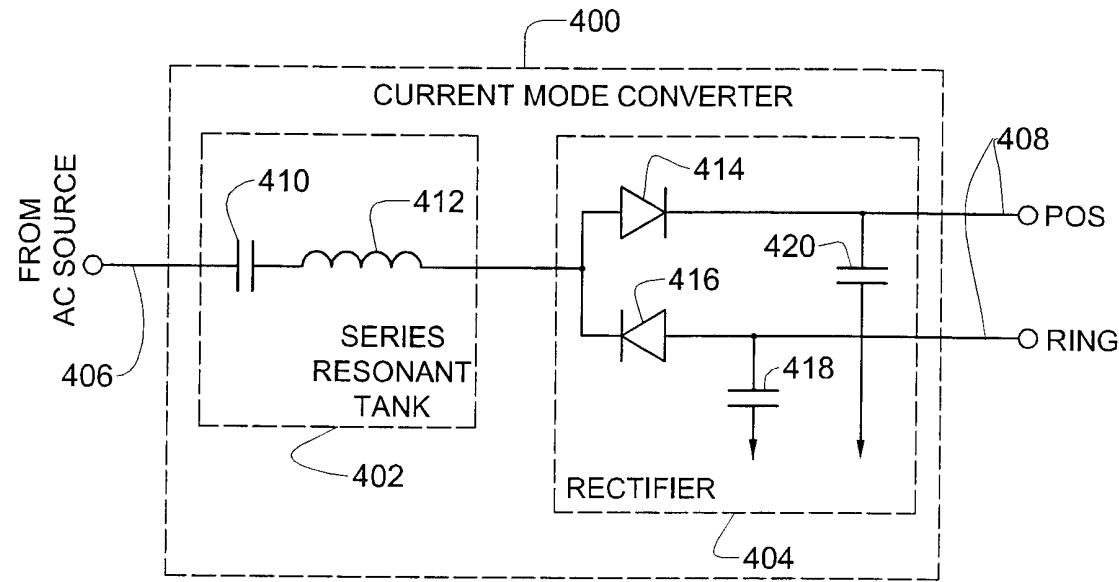


FIG. 4

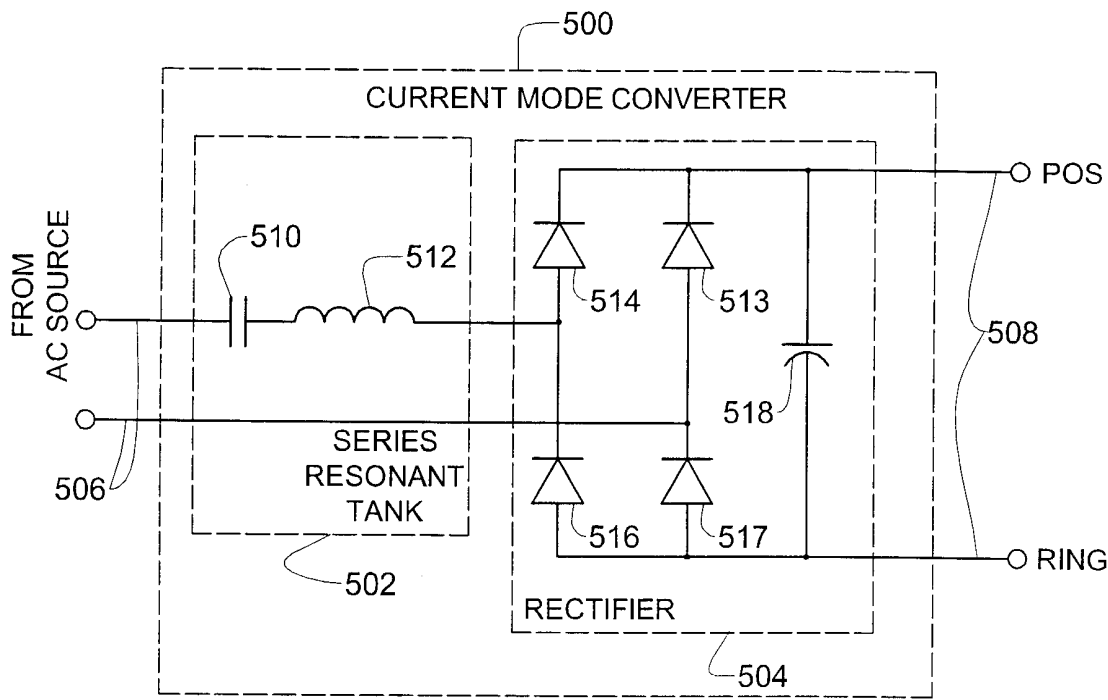
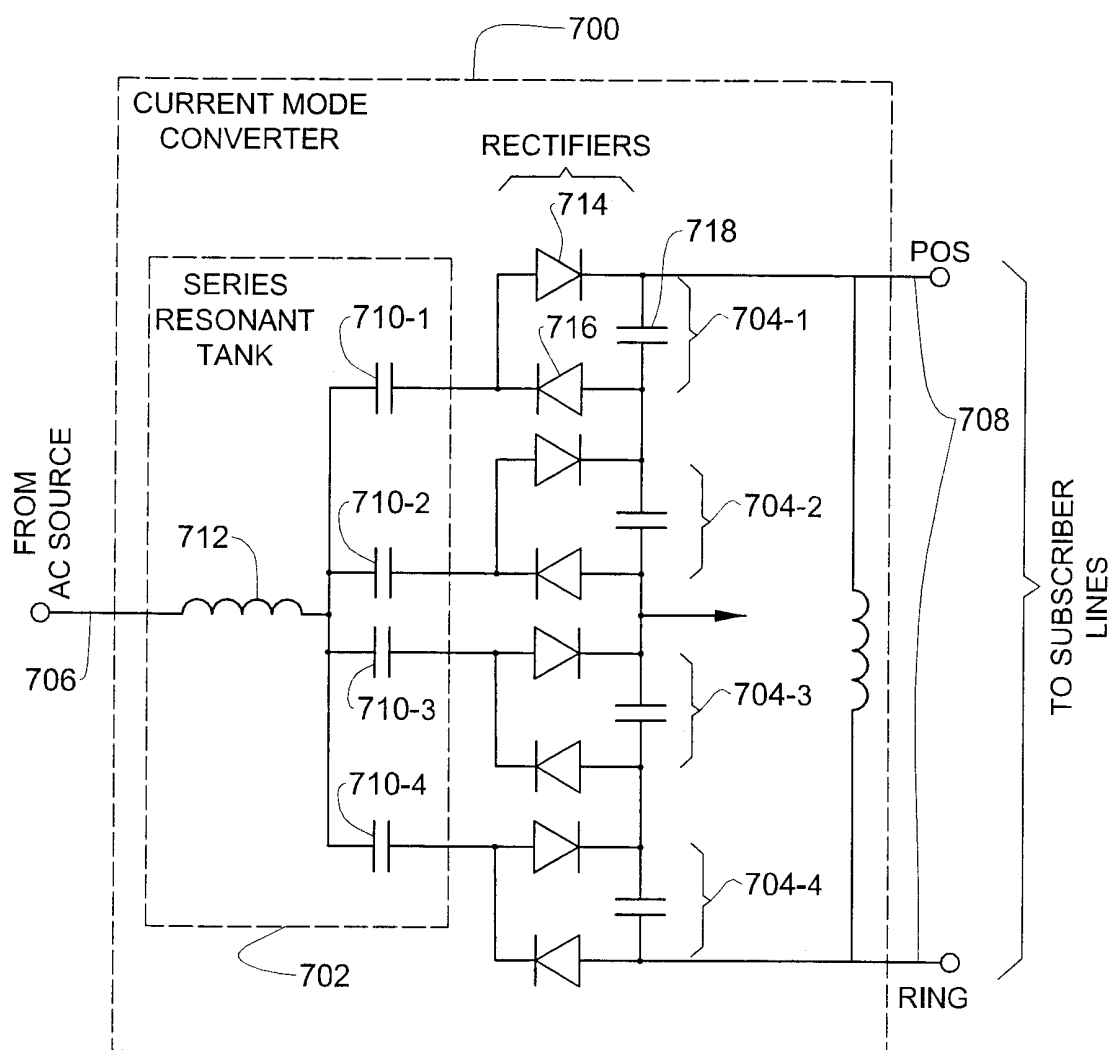
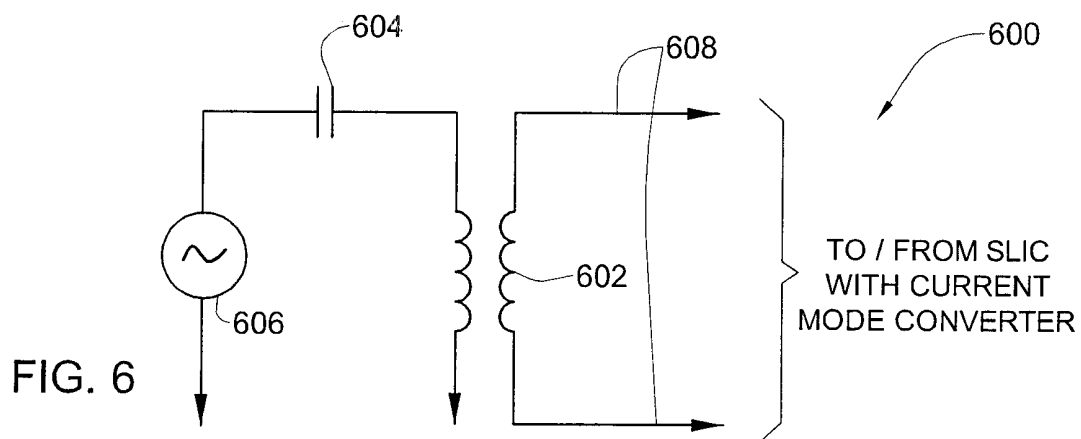


FIG. 5

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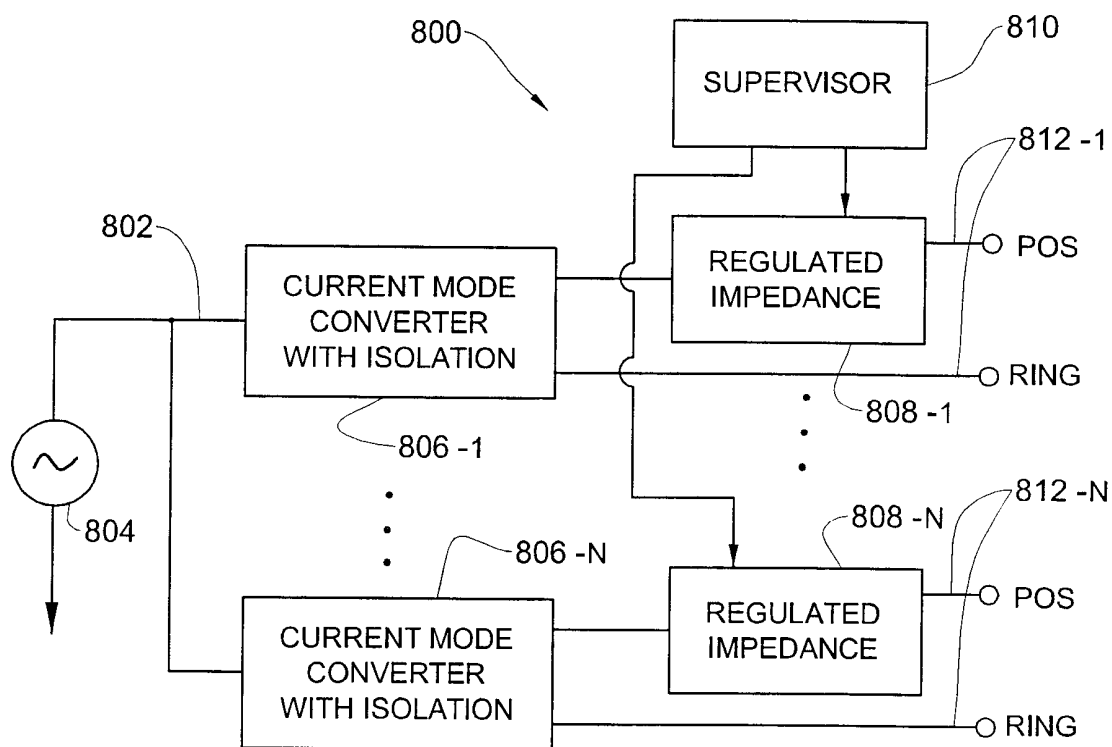


FIG. 8

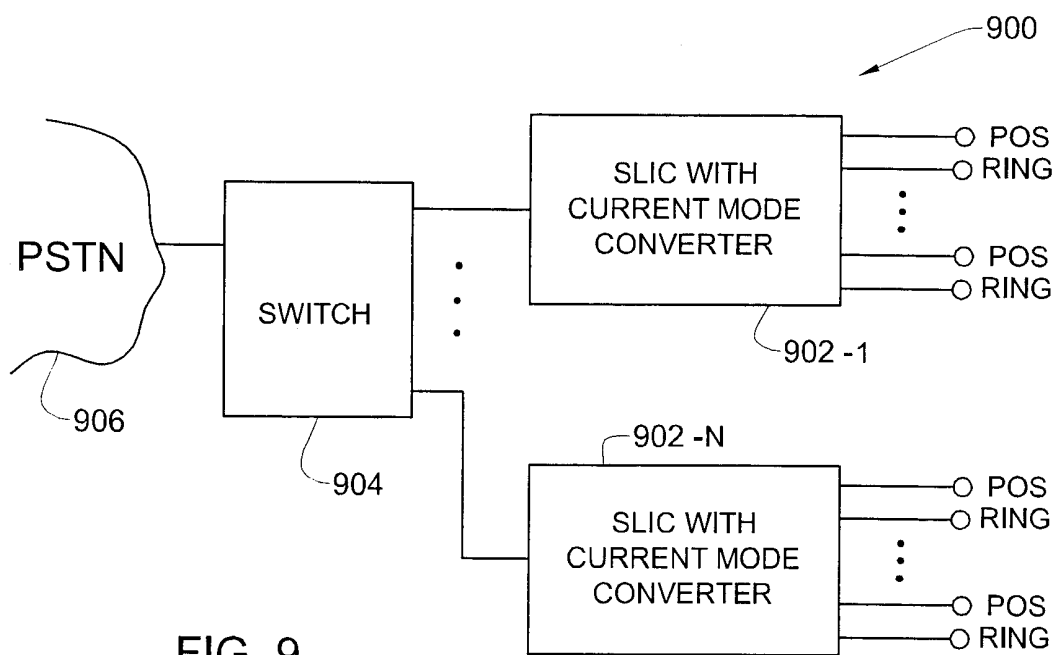


FIG. 9