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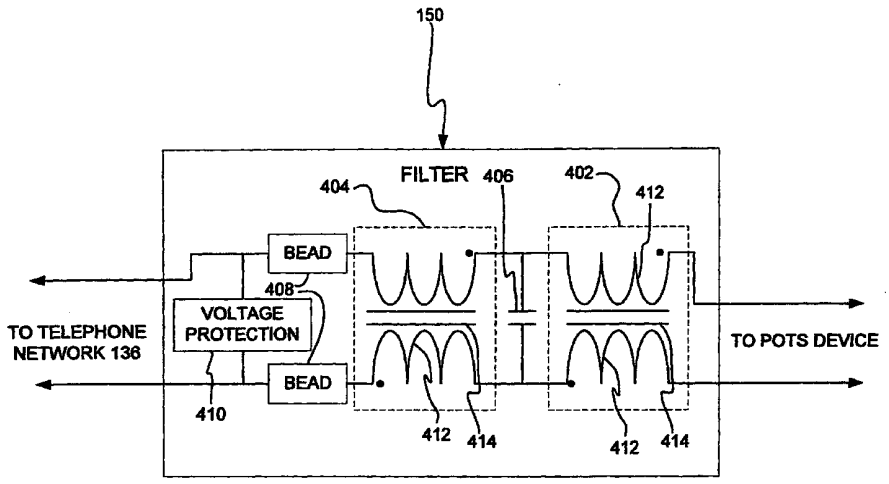
(54) Title: ODD-ORDER LOW-PASS POTS DEVICE FILTER



(57) Abstract: An odd-order low-pass filter is disclosed for being interposed between a home telephone wiring network and a POTS, or voice-band device to separate voice-band signals from higher frequency signals, such as ADSL signals and home networking signals. The filter topology is substantially symmetric so that the filter is reversible in that either end of the filter may be directly coupled to the home telephone wiring network without impairing high frequency signal performance or the filter characteristic of the filter. In one embodiment, the filter is a third-order, or three-pole filter (402, 404, 406) with a single capacitor (406) disposed between a pair of inductors. According to this configuration, regardless of which of the inductors is coupled closest to the home telephone wiring network, the capacitor is separated from the home telephone network by an inductor to prevent frequency signals, such as ADSL signals, from being shorted across the capacitor. Hence, the filter will function satisfactorily regardless of the direction in which it is installed.

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ODD-ORDER LOW-PASS POTS DEVICE FILTER

By Ting Sun and Brian L. Hinman

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to low pass filters and, more particularly, a reversible, odd-order low-pass filter for separating xDSL and home networking signals from voice-band signals existing on the same pair of copper wires.

2. Description of the Background Art

With the advent of xDSL and home networking data transmission technologies, it may be desirable to have xDSL signals, home networking signals, or both present on a home telephone wiring network simultaneously with voice-band signals. Voice-band signals are commonly referred to as POTS (Plain Old Telephone Service) signals. Providing xDSL service, home networking, and POTS over standard telephone lines permits the home telephone wiring network to operate as a local area network (LAN), while at the same time permitting voice-band and xDSL service to be transmitted across the home telephone wiring network.

Despite the advantages of providing xDSL, home networking, and POTS signals simultaneously over a common network, it is desirable to prevent energy from the xDSL and/or home networking signal carriers from reaching voice-band, or POTS, appliances coupled to the network. Voice-band appliances may include, for example, telephone sets, facsimile machines, 56K modems, and the like. Indeed, energy from the xDSL or home networking signal carriers may cause the non-linear behavior of the voice-band appliances to create noise into the POTS connection. Further preventing xDSL and home networking signals from reaching voice-band appliances protects the xDSL and home networking transports from high-frequency inter-modulation products of the voice-band appliances.

In addition, voice-band appliances typically undergo impedance changes during operation. For example, state changes in a POTS device such as on / off hook, dialing, and ringing tend to affect the impedance of the POTS device. This change in impedance, unless isolated from the xDSL and home networking devices, may limit the throughput of the xDSL

or home networking devices and may require dynamic bit reloading inter-modulation and line retraining.

Accordingly, a need exists to provide a system and method for preventing energy from xDSL and home network signal carriers from reaching voice-band appliances such as telephones, facsimile machines, and 56K modems. Another need exists to provide a system and method for isolating xDSL and home network (homePNA) devices from the impedance fluctuations of voice-band appliances. Moreover, an additional need exits to provide a system and method for separating, or isolating, voice-band appliances from ADSL and home PNA devices that is robust, inexpensive, and easy to install.

SUMMARY OF THE INVENTION

The present invention overcomes or substantially alleviates prior problems associated with systems and methods for separating or isolating voice-band appliances from xDSL and home PNA devices. In general, the present invention provides a reversible odd-order low-pass filter that may be disposed between a POTS device and a home telephone wiring network to isolate the POTS device from certain higher frequency signals that may be present on the home telephone wiring network. Moreover, the filter topology is substantially symmetric in that it features reversible plug-in capability so that either end of the filter may be coupled to the home telephone wiring network without interfering with the filtering function of the filter and without shorting the higher frequency signals on the home telephone wiring network. Further, the filter presents a relatively low insertion loss so that the filter does not cause significant attenuation of the POTS signal as it passes through the filter, thus not impairing the operation of the associated POTS device.

In one embodiment, the low-pass filter is a passive third-order, or 3 pole, low-pass filter design scheme based on a 600 Ohm balanced network and includes a pair of coupled inductors separated by a capacitor. Due to the inter-winding capacitance of the inductors, the frequency response of the low-pass filter appears as a somewhat elliptic function in that the filter provides a steep attenuation above the cutoff frequency.

Another embodiment is a fifth-order, or 5 pole, low pass filter. This embodiment includes three pairs of coupled inductors. A capacitor is disposed between each pair of inductors. Again, due to the inter-winding capacitance of the inductors, the frequency response of the low-pass filter appears as a somewhat elliptic function.

This odd-order design is advantageous in that it effectively and inexpensively isolates high frequency signals on a home telephone wiring network from reaching POTS devices as well as preventing the impedance changes of the POTS devices from interfering with the ADSL or home networking service. Additionally, since the odd-order filter does not employ a capacitor disposed outside of the inductors, the filter is reversible in that either end of the filter may be coupled to the home telephone wiring network without shorting the high frequency signals across a capacitor or otherwise impairing the filter characteristic of the filter. Thus, even if the end user installs the filter "backwards," the filter will still generate the same frequency response and function

satisfactorily without shorting the higher frequency signals on the home telephone wiring network.

Other advantages and features of the present invention will be apparent from the drawings and detailed description as set forth below.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating an ADSL service network;

FIG. 2 is a block diagram of the splitter of FIG. 1;

FIG. 3 is a block diagram illustrating an alternative ADSL service network;

FIG. 4 illustrates details of the filter of FIGS. 1 and 3;

FIG. 5 illustrates the filter of FIG. 4 in a reversed installation configuration;

FIG. 6 illustrates the frequency response of the filter of FIG. 4; and

FIG. 7 illustrates another embodiment of the filter of FIGS. 1 and 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 illustrates an ADSL service network 100 that includes a central office 102 including a Digital Subscriber Line Access Muliplexer (DSLAM) 103 and a home 104 coupled by a loop 106. As shown, the central office 102 includes an ADSL transceiver unit 110 and a loop interface 112. The loop interface 112 includes a high pass filter 114 and a low pass filter 116 to split high frequency ADSL components of the loop signal and the lower frequency POTS (Plain Old Telephone Service) components of the loop signal. In this configuration, the high pass filter 114 passes signals in the ADSL frequency range to the broadband network 120 via the ADSL modem 110. Likewise, the low pass filter 116 passes the lower frequency POTS signals to the narrow band network 122 over a PSTN (Public Switched Telephone Network) line.

The home 104 is shown as including a splitter 130, an ADSL modem 132, a computer 134, a telephone, or POTS, a home telephone wiring network 136, and POTS devices, such as telephone 138 and facsimile machine 139. Further, personal computers 141 and 143 are illustrated as being coupled to the network 136. The computer 141 is shown as having an external HPNA network interface card 145. The computer 143 has an internal HPNA card (not shown) so that the computers 141 and 143 may communicate using high-frequency home networking signals over the network 136. While the ADSL modem 132 is illustrated as being disposed outside of the computer 134, those skilled in the art will appreciate that the ADSL modem 132 could also be positioned inside the computer 134.

The splitter 130 splits the incoming signal into high and low frequency components. As discussed in more detail below with reference to FIG. 2, the splitter 130 routes the high frequency component along line 140 to the ADSL modem 132, which is coupled to a network device, such as a computer 134, by a line 142. Likewise, the splitter 130 routes the low frequency, or POTS, component of the incoming signal to the home telephone wiring network 136 along line 144. The telephone 138, the facsimile machine 139, as well as other POTS devices (*e.g.* 56k modems, etc.) (not shown), are coupled to the home telephone wiring network 136 by lines 148.

A low-pass filter 150 is shown as being disposed between each POTS device and the home telephone wiring network 136. As discussed in more detail below, the low-pass filters 150 prevent the home networking high frequency energy on the home telephone wiring network 136 from reaching the POTS voice-band appliances, such as the

telephone 138 and the facsimile machine 139. The filters 150 substantially reduce, or eliminate, the non-linear behavior of the voice-band appliances from creating noise onto the home telephone wiring network 136 and protects home networking transports from high-frequency inter-modulation products from the voice-band appliances.

Moreover, the low-pass filters 150 isolate the home networking, or home PNA (Home Phoneline Networking Alliance), transmission medium from the voice-band appliances' impedance changes during their operation. As those skilled in the art will appreciate, voice-band appliances undergo impedance changes as they undergo state changes, such as on /off hook, dialing, ringing, etc. Isolating these impedance changes from the high frequency transmission medium, substantially alleviates the need for dynamically performing bit reloading inter-modulation and line retraining, prevents loss of data transfer rate, and helps to maintain high data throughput for the home networking environment.

Additional details concerning ADSL equipment are found in Standards Project for Interfaces Relating to Carrier to Customer Connection of Asymmetrical Digital Subscriber Line (ADSL) Equipment, T1E1.4/97-007R6, T1.413 Issue 2, edited by John Bingham and Frank van der Putten, dated September 26, 1997, which is incorporated herein by reference.

FIG. 2 illustrates details of the splitter 130 of FIG. 1. As shown, the splitter 130 includes a high pass filter 202 and a low pass filter 204 coupled to the loop 106 via lines 206 and 208 respectively. The high pass filter 202 permits higher frequency signals, such as ADSL signals, to pass from the loop 106 to the ADSL modem 132 (FIG. 1) while preventing the lower frequency POTS signals from entering onto the line 140 and potentially interfering with the operation of the ADSL modem 132. Similarly, the low pass filter 204 permits the lower frequency POTS signals to pass onto the home telephone wiring network 136 while preventing higher frequency signals, such as ADSL signals, from entering onto the home telephone wiring network 136.

FIG. 3 illustrates an alternative ADSL network 300. The network 300 differs from that illustrated in FIG. 1 in that it does not include the splitter 130 disposed between the loop 106 and the home telephone wiring network 136 or the ADSL modem 132. As such, the loop 106 is directly coupled to the home telephone wiring network 136 via the line 144 and, therefore, both ADSL, home networking, and POTS (or voice-band) signals pass simultaneously over the home telephone wiring network 136. Like the network 100

shown in FIG. 1, the network 300 includes low pass filters 150 disposed between the home telephone wiring network 136 and the voice-band appliances 138 and 139. The low-pass filters 150 generally prevent the higher frequency signals from interfering with operation of the associated voice-band or POTS devices 138 and 139 and separate the lower frequency voice band signals from the signals in the ADSL spectrum and the signals in the home networking spectrum. These higher frequency signals may include, for example, ADSL signals, home networking signals, or both.

FIG. 4 illustrates the topology of one embodiment of the filter 150 shown in FIGS. 1 and 3. The filter 150 of FIG. 4 is a reversible 3-pole, third-order, low-pass filter and includes first and second coupled inductors, or transformers, 402 and 404 with a single capacitor 406 disposed therebetween. Moreover, the filter 150 is shown as having a pair of ferrite beads 408 and a hazardous transient voltage protection circuit 410. In a preferred embodiment, the hazardous transient voltage protection circuit 410 comprises a sidactor transient voltage suppressor.

The filter 150 is further illustrated as being disposed between the home telephone wiring network 136 and a POTS device, such as the telephone 138 (FIG. 1) with the inductor 404 closest to or adjacent the home telephone wiring network 136. A significant advantage of the design of FIG. 4 is that the capacitor 406 is disposed between the two coupled inductors 402 and 406 so that regardless of which end of the filter 150 is coupled to the home telephone wiring network 136, the capacitor 406 will not short a high frequency signal, such as an ADSL or home networking signal, on the home telephone wiring network 136. This advantage makes the filter 150 reversible in that either end of the filter 150 may be coupled to the home telephone wiring network 136 without shorting high frequency signals across a capacitor or otherwise impairing transmission of high frequency signals.

The first and second coupled inductors 402 and 404 are shown as being configured identical to one another. The first coupled inductor 402 includes a pair of windings 412 wrapped about a core 414. Advantageously, each of the windings 412 has an inductance of about 5.5 mH or more. This coupled inductor configuration yields a relatively high inductance as it includes both the self inductance of each winding together with the mutual inductance of the coupled inductor and thereby produces better high frequency attenuation. Further, the interwinding capacitance of the coupled inductors

402 and 404 enhances the filter characteristic of the filter 150 by contributing to a steeper frequency roll off as shown in FIG. 6.

The ferrite beads 408 reduce high frequency, common mode noise as well as provide EMI suppression. The hazardous transient voltage protection circuit 410 is conventional and is used to protect the associated POTS device from being damaged by transient voltages, such as those that might be produced by a lightning strike, for example.

FIG. 5 illustrates the reversible nature of the filter 150 of FIG. 4. That is, FIG. 5 shows the filter 150 of FIG. 4 coupled to the network 136 (FIG. 1) in a manner opposite that shown in FIG. 4. As illustrated in FIG. 5, the filter 150 is disposed between a POTS device, such as the telephone 138 (FIG. 1) and the home telephone wiring network 136 with the home telephone wiring network 136 being coupled to the filter adjacent to the inductor 402. It should be noted that in the installation of FIG. 5, like in the installation of FIG. 4, the capacitor 406 is separated from the home telephone wiring network 136 by a coupled inductor. In FIG. 4, the capacitor 406 is separated from the home telephone wiring network 136 by the coupled inductor, or transformer, 404 whereas in FIG. 5, the capacitor 406 is separated from the home telephone wiring network 136 by the coupled inductor 402.

As discussed above, separating the capacitor 406 from the home telephone wiring network 136 by an inductor, regardless of the direction in which the filter 150 is installed, prevents the capacitor 136 from shorting high frequency signals, such as ADSL or home network signals, that might be present on the home telephone wiring network 136.

FIG. 6 illustrates the frequency response of the filter 150 described above in FIGS. 4 and 5. In particular, FIG. 6 depicts the filter frequency response based on an approximately 600 Ohm balanced impedance. As shown, the frequency response permits the filter 150 to effectively function as a low-pass filter, permitting signals in the voice band (about 2 kHz – 6 kHz), but preventing higher frequency signals, such as those above about 30 kHz from passing therethrough.

Specifically, as shown in FIG. 6, the filter 150 provides negligible, if any, attenuation of voice-band signals in the range of 2 kHz to 6 kHz. For signals above 25 kHz, however, the filter 150 provides considerable attenuation. As an example, for ADSL signals in the 100 kHz range, the attenuation is about 55 dB. Another example shows that a 1 MHz signal would be attenuated by close to 60 dB.

FIG. 7 illustrates another embodiment of the odd-order filter 150 shown in FIGS. 1 and 3. This embodiment is a reversible fifth-order, or five-pole, filter. As shown, the filter 150 of FIG. 7 includes three coupled inductors 602, 604, and 606. Each of these coupled inductors 602, 604, and 606 is configured identical to the coupled inductors 402 and 406 described above in connection with FIG. 4 and, therefore, no additional description of the coupled inductors 602, 604, and 606 is necessary. A first capacitor 610 is shown as being disposed between the coupled inductors 602 and 604. Likewise, a second capacitor 612 is disposed between the coupled inductors 604 and 606.

Further, the fifth-order filter 150 shown in FIG. 7 is reversible in the same general manner that the third-order filter 150 shown in FIG. 4 is reversible. That is, in FIG. 7, the home telephone wiring network 136 is illustrated as being connected to the side of the filter 150 closest to the coupled inductor 602. However, the filter 150 could also be connected to the home telephone wiring network 136 with the home telephone wiring network 136 connected to the side of the filter closest to the coupled inductor 606. In both of these configurations, the capacitors 610 and 612 are separated from the home telephone wiring network 136 by at least one of the coupled inductors 602, 604, or 606. Consequently, in either configuration, the filter 150 will function satisfactorily without the risk of shorting a high frequency signal over one of the capacitors 610 or 650.

Hence, as discussed above, by providing an odd-order filter disposed between a POTS device and the home telephone wiring network 136, the filter 150 is reversible and may be installed with either side coupled to the home telephone wiring network 136 without shorting or otherwise impairing a high frequency signal, such as an ADSL or home networking signal, on the home telephone wiring network 136.

The invention has been described above with reference to specific embodiments. It will, however, be evident that various modifications and changes may be made thereto without departing from the broader spirit and scope of the invention as set forth in the appended claims. The foregoing description and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A reversible odd-order low-pass filter for insertion between a POTS device and a home telephone wiring network to separate certain high frequency signals on the home telephone wiring network from the POTS device, comprising:

a first coupled inductor having a pair of windings wrapped about a core;

a second coupled inductor having a pair of windings wrapped about a core;

a single capacitor disposed between the first and the second coupled inductors and separated from the home telephone wiring network by either the first or the second coupled inductor to prevent high frequency signals from being shorted across the capacitor regardless of whether the home telephone wiring network is coupled to the filter adjacent to the first or the second coupled inductor.

2. The reversible odd-order filter according to claim 1, further comprising at least one ferrite bead for reducing common mode noise through the filter.

3. The reversible odd-order filter according to claim 1, further comprising a transient voltage suppressor for protecting the POTS device from hazardous transient voltages.

4. The reversible odd-order filter according to claim 1, wherein each winding has an inductance of about 5.5 mH.

5. A reversible third-order filter for separating a voice-band device from certain high frequency signals on a home telephone wiring network, comprising:

a first inductor;

a second inductor;

a single capacitor disposed between the first and second inductors so that when the filter is interposed between the home telephone wiring network and the voice-band device, either the first inductor or the second inductor separates the single capacitor from the home telephone wiring network to prevent certain high frequency signals on the home telephone wiring network from shorting across the single capacitor regardless of whether the first inductor or the second inductor is disposed closest to the home telephone wiring network.

6. The reversible filter according to claim 5, wherein the first inductor further comprises a coupled inductor.

7. The reversible filter according to claim 6, wherein the coupled inductor further comprises a pair of windings wrapped about a core.

8. The reversible filter according to claim 7, wherein each winding has an impedance equal to or greater than about 5.5 mH.

9. The reversible filter according to claim 5, further comprising at least one ferrite bead for reducing common mode noise through the filter.

10. The reversible filter according to claim 5, further comprising a transient voltage suppressor for protecting the POTS device from hazardous transient voltages.

11. A reversible fifth-order filter for separating a voice-band device from certain high frequency signals on a home telephone wiring network, comprising:

a first inductor;

a second inductor;

a third inductor; and

first and second capacitors, the first capacitor being disposed between the first and second inductors and the second capacitor disposed between the second and third inductors so that when the filter is interposed between the home telephone wiring network and the voice-band device, either the first inductor or the third inductor separates the first and second capacitors from the home telephone wiring network to prevent certain high frequency signals on the home telephone wiring network from shorting across the either the first or the second capacitor, regardless of whether the first inductor or the third inductor is disposed closest to the home telephone wiring network.

12. The reversible filter according to claim 11, wherein the first inductor further comprises a coupled inductor.

13. The reversible filter according to claim 12, wherein the coupled inductor further comprises a pair of windings wrapped about a core.

14. The reversible filter according to claim 13, wherein each winding has an impedance equal to or greater than about 5.5 mH.

15. The reversible filter according to claim 11, further comprising at least one ferrite bead disposed for reducing common mode noise through the filter.

16. The reversible filter according to claim 11, further comprising a transient voltage suppressor for protecting the POTS device from hazardous transient voltages.

17. The reversible filter according to claim 5, wherein the first inductor further comprises a pair of inductors.

18. The reversible filter according to claim 17, wherein the pair of inductors further include a pair of windings wrapped about a core.

19. The reversible filter according to claim 17, further comprising at least one ferrite bead for reducing common mode noise through the filter.

20. The reversible filter according to claim 17, further comprising a transient voltage suppressor for protecting the POTS device from hazardous transient voltages.

21. The reversible filter according to claim 11, wherein the first inductor further comprises a pair of inductors.

22. The reversible filter according to claim 21, wherein the pair of inductors further include a pair of windings wrapped about a core.

23. The reversible filter according to claim 21, further comprising at least one ferrite bead disposed for reducing common mode noise through the filter.

24. The reversible filter according to claim 21, further comprising a transient voltage suppressor for protecting the POTS device from hazardous transient voltages.

25. A reversible odd-order low-pass filter for insertion between a POTS device and a telephone wiring network to separate certain high frequency signals on the telephone wiring network from the POTS device, comprising:

a first pair of inductors;

a second pair of inductors;

a single capacitor disposed between the first and the second pairs of inductors and separated from the telephone wiring network by either the first or the second pair of inductors to prevent high frequency signals from being shorted across the capacitor regardless of whether the telephone wiring network is coupled to the filter adjacent to the first or the second pair of inductors.

26. The reversible odd-order filter according to claim 25, further comprising at least one ferrite bead for reducing common mode noise through the filter.

27. The reversible odd-order filter according to claim 25, further comprising a transient voltage suppressor for protecting the POTS device from hazardous transient voltages.

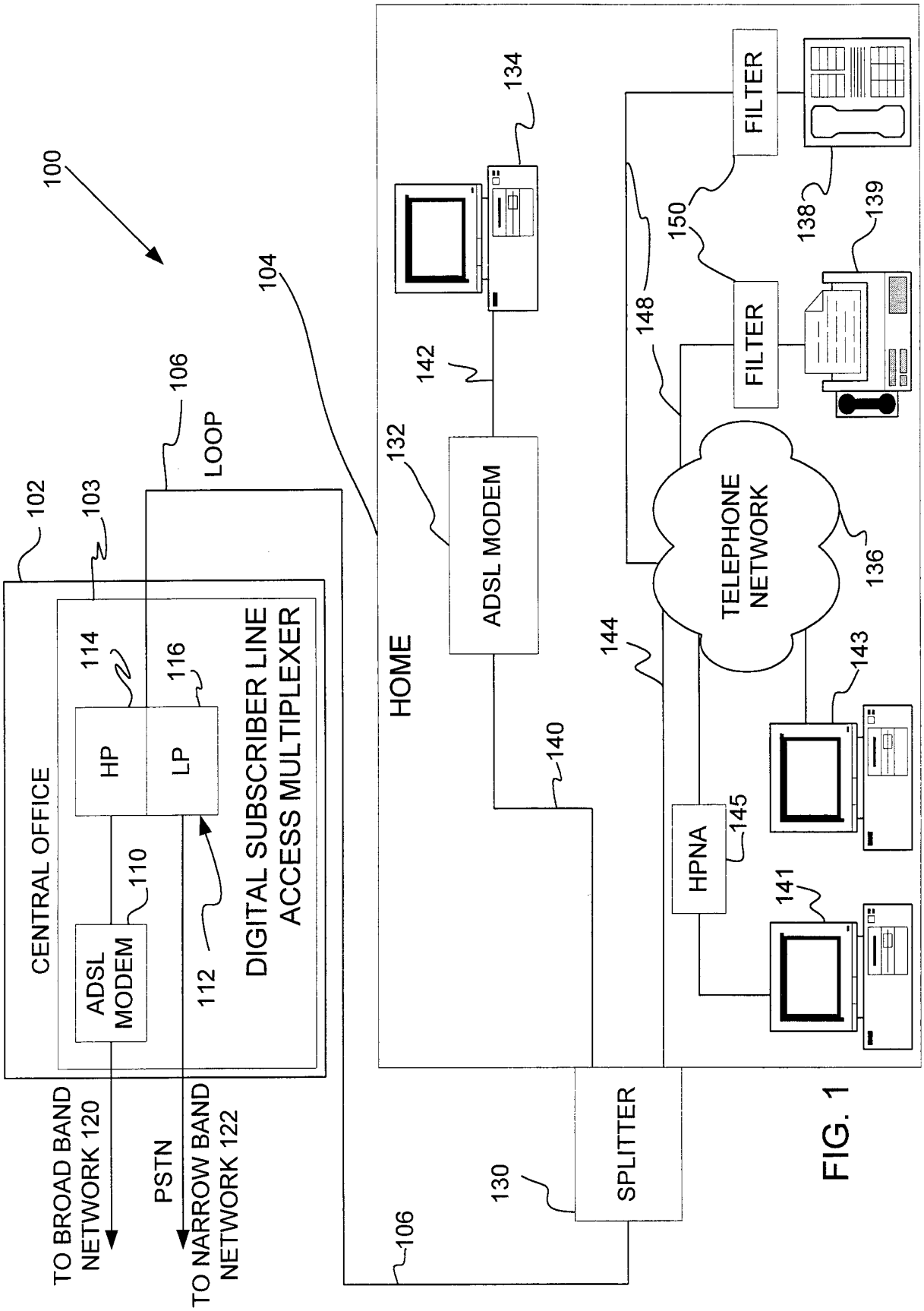
28. A reversible filter for insertion between a POTS device and a telephone wiring network to separate certain high frequency signals on the telephone wiring network from the POTS device, comprising:

a first and a second pair of inductors, each pair of inductors having an inner end and an outer end; and

a capacitor coupled to the inner ends of the first and second pair of inductors, said outer ends of the first and second pairs of inductors being connectable between the POTS device and the telephone wiring network.

29. The reversible filter according to claim 28, further comprising at least one ferrite bead for reducing common mode noise through the filter.

30. The reversible filter according to claim 28, further comprising a transient voltage suppressor for protecting the POTS device from hazardous transient voltage.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104
106
LOOP
102
103
CENTRAL OFFICE
114
116
HP
LP
ADSL MODEM
110
112
DIGITAL SUBSCRIBER LINE ACCESS MULTIPLEXER
TO BROAD BAND NETWORK 120
PSTN
TO NARROW BAND NETWORK 122
106
130
SPLITTER
HOME
132
ADSL MODEM
134
142
140
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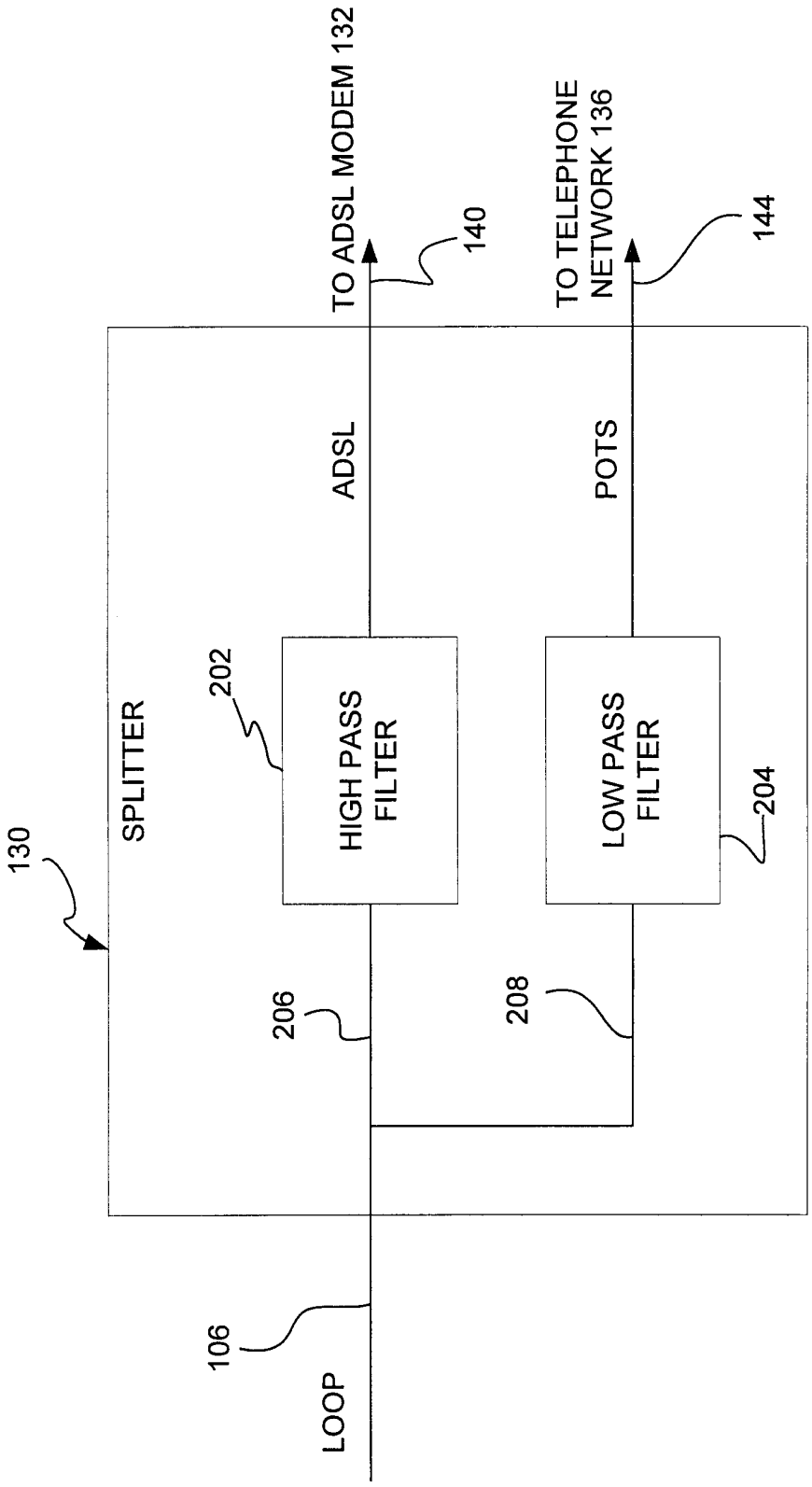
TELEPHONE NETWORK
136
148
150
FILTER
FILTER
138
139
143
HPNA
145
141

FIG. 1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140
TO TELEPHONE NETWORK 136
144
ADSL
POTS
202
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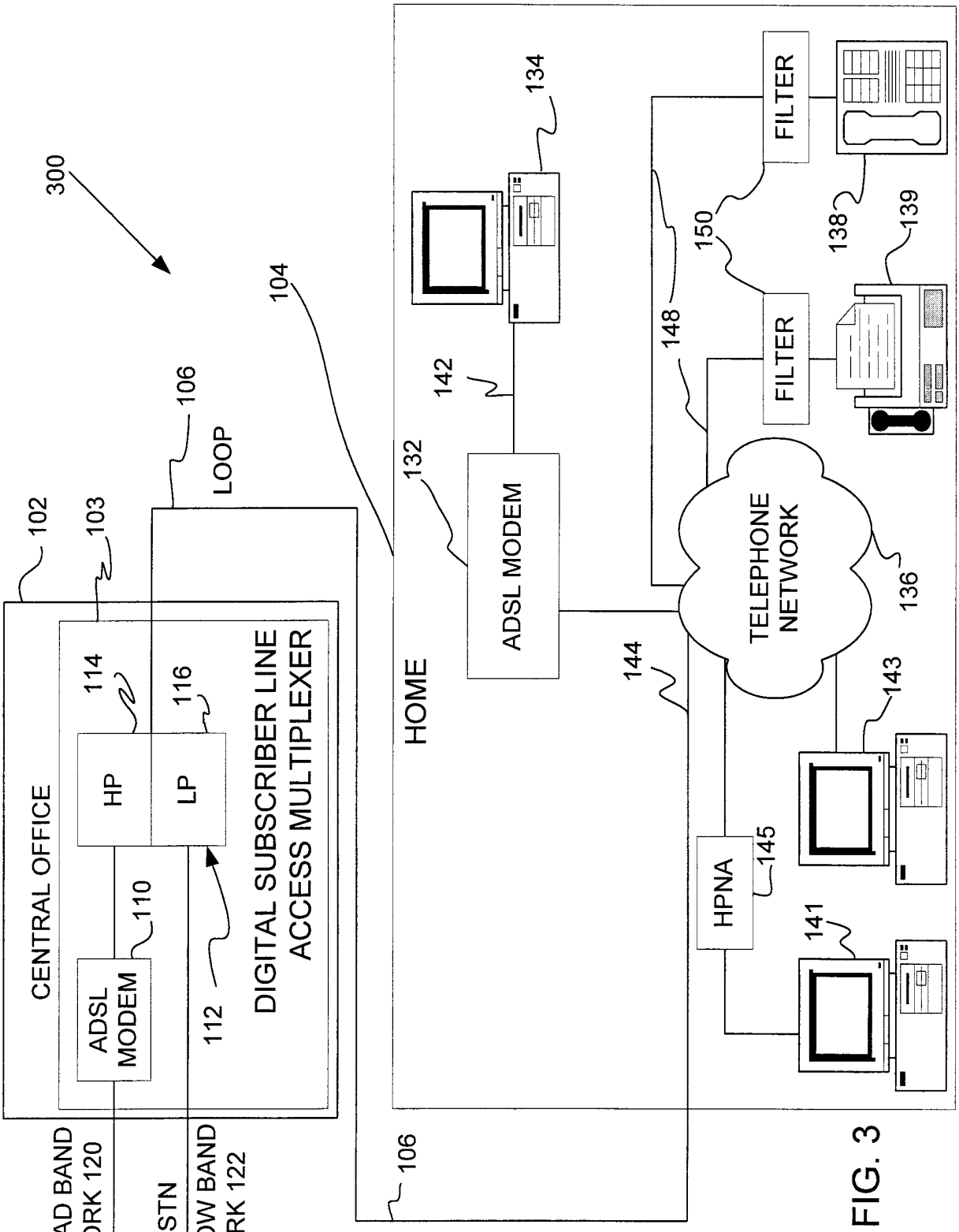
LOW PASS FILTER
204
SPLITTER
130
206
208
106
LOOP

FIG. 2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LOOP
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114
116
TO BROAD BAND NETWORK 120
PSTN
TO NARROW BAND NETWORK 122
HOME
ADSL MODEM
132
134
142
144
148
150
FILTER
FILTER
TELEPHONE NETWORK
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138
139
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HPNA
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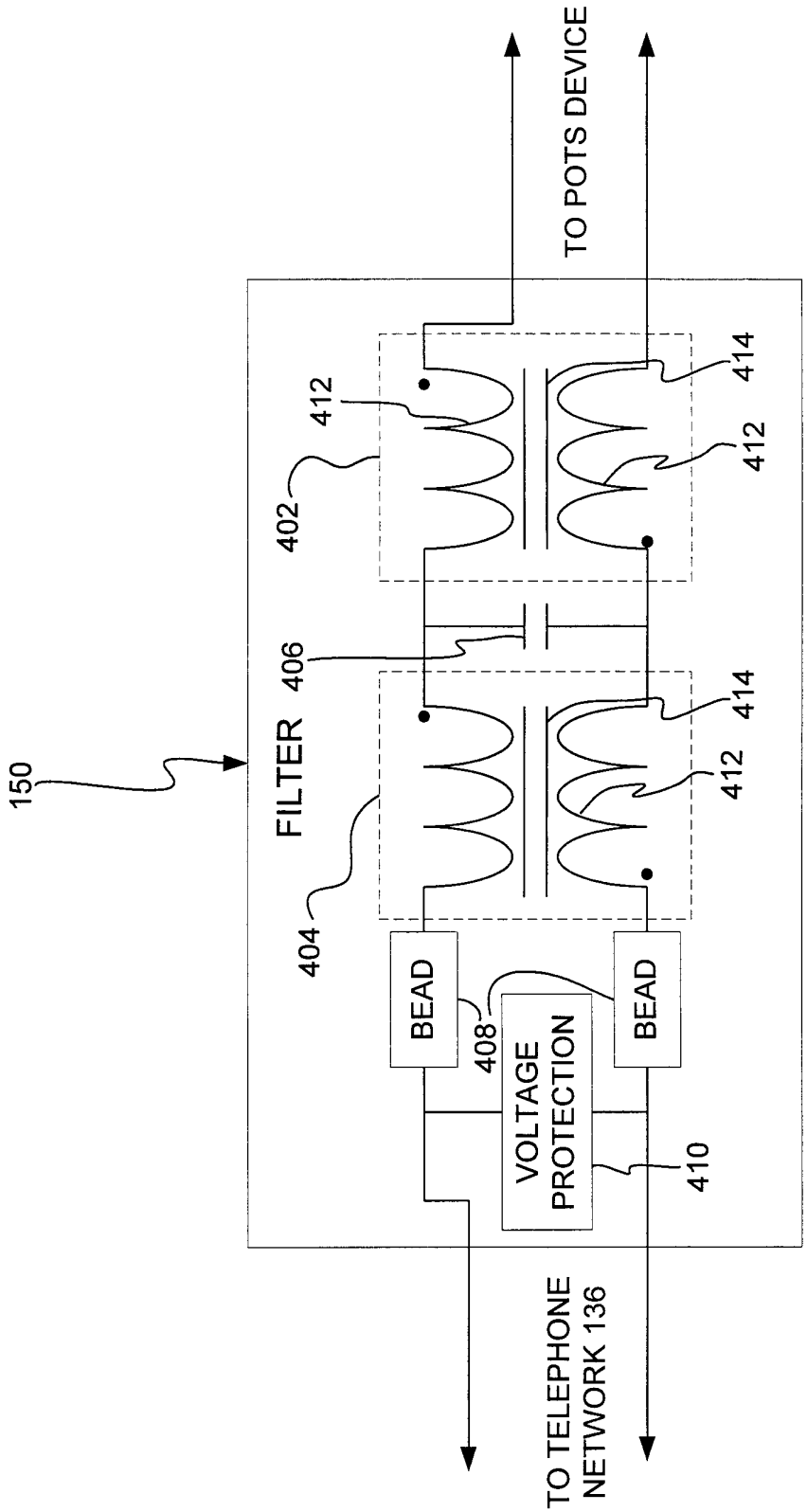
FIG. 3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FILTER
402
404
406
412
414
412
414
412
BEAD
408
VOLTAGE PROTECTION
BEAD
410
TO POTS DEVICE
TO TELEPHONE NETWORK 136

FIG. 4

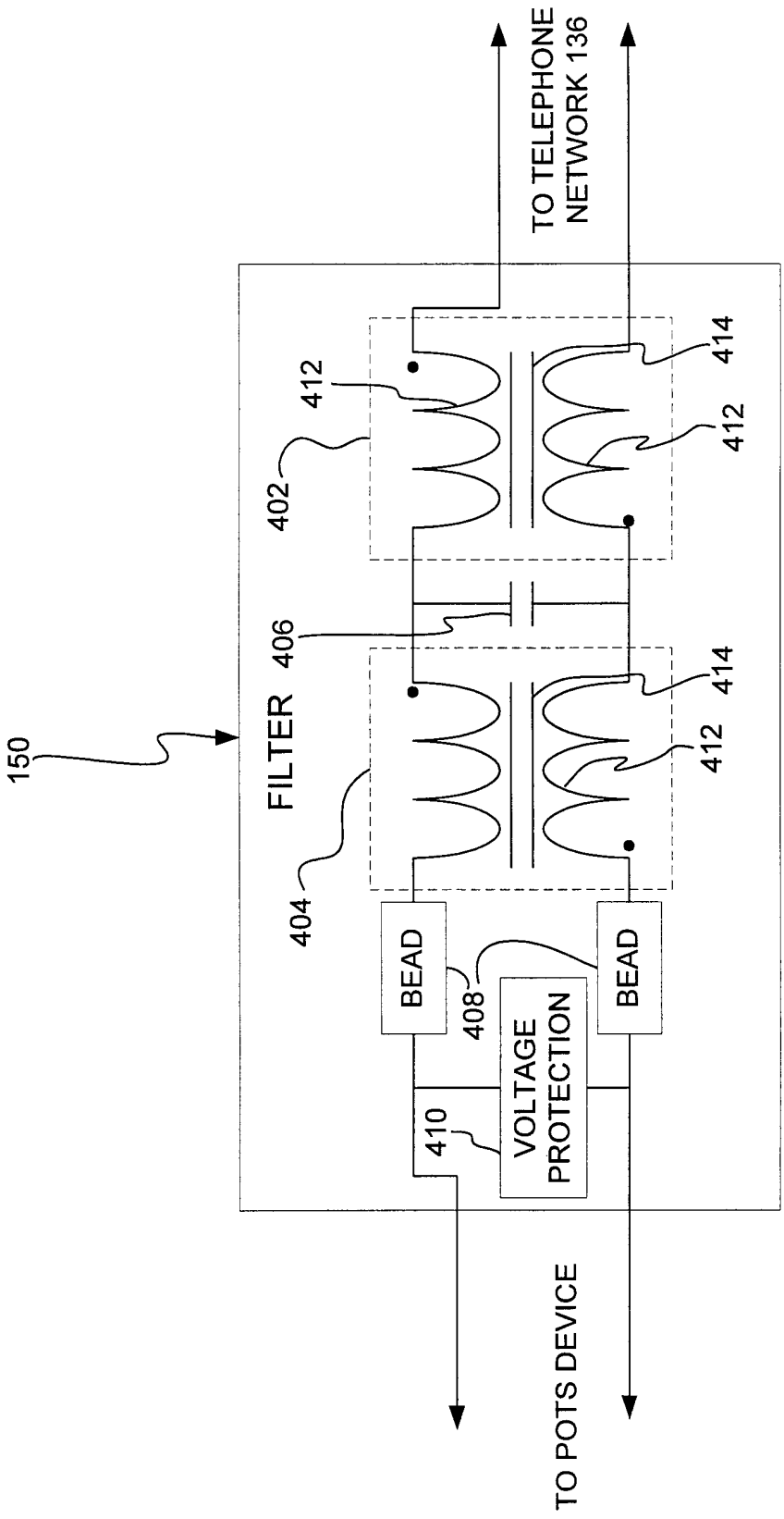
TO TELEPHONE NETWORK 136
150
FILTER
402
404
406
412
414
BEAD
408
BEAD
VOLTAGE PROTECTION
410
TO POTS DEVICE

FIG. 5

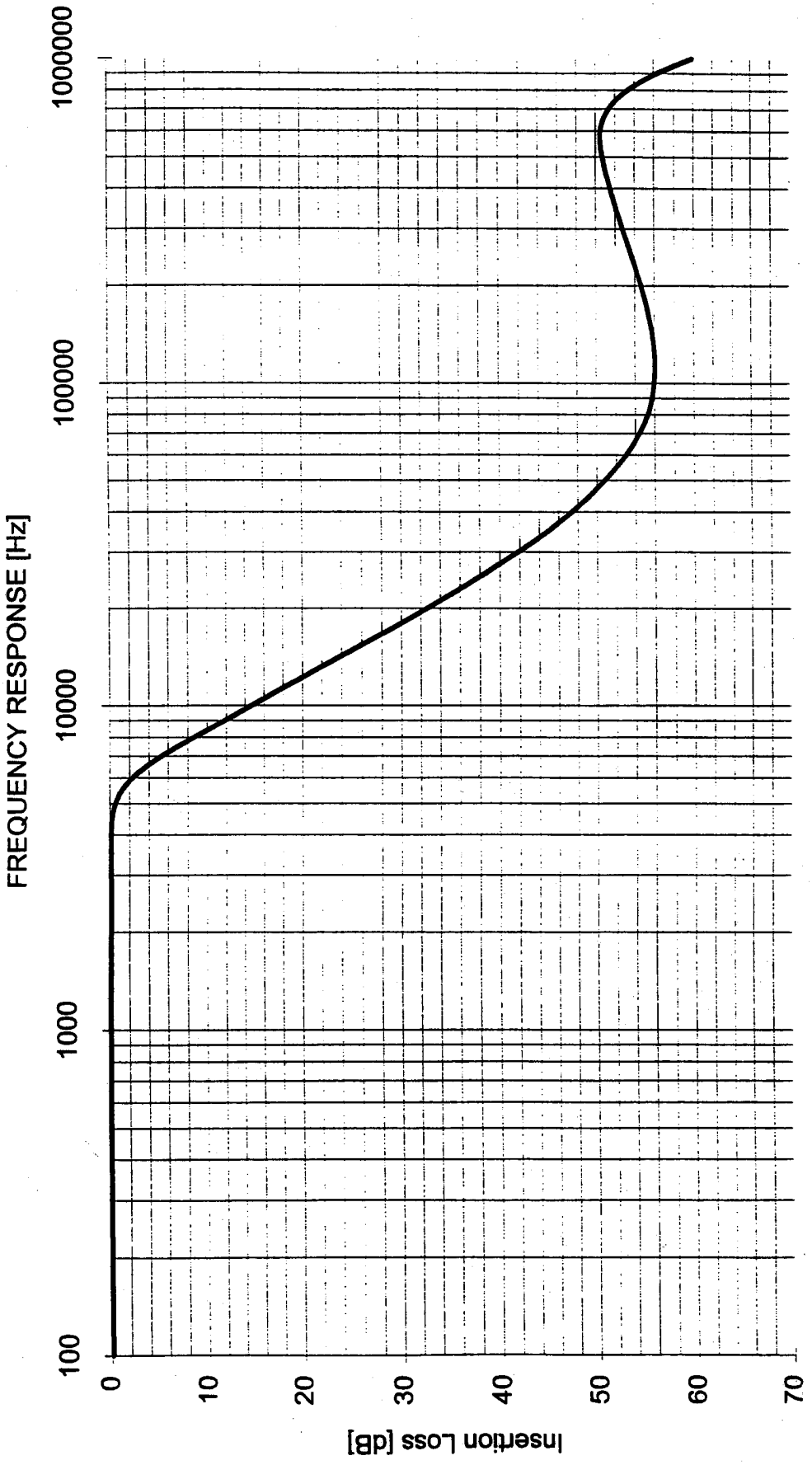
FREQUENCY RESPONSE [Hz]
100
1000
10000
100000
1000000
Insertion Loss [dB]
0
10
20
30
40
50
60
70

FIG. 6

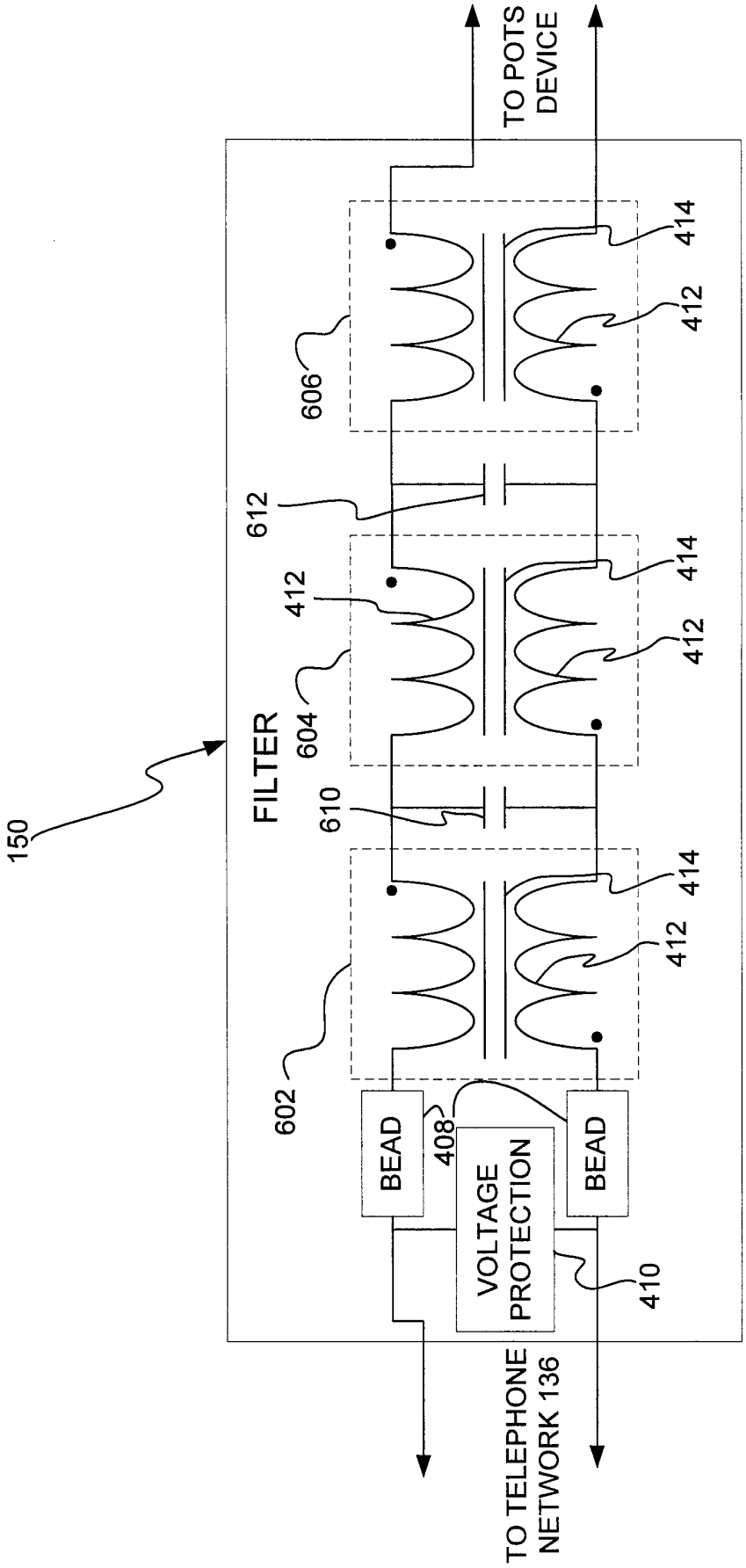
150
FILTER
602
604
606
610
612
412
414
408
BEAD
BEAD
VOLTAGE PROTECTION
410
TO POTS DEVICE
TO TELEPHONE NETWORK 136

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/18329

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :H04M 1/00
US CL : 379/399, 397

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. : 379/397, 398, 399, 400

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

Please See Extra Sheet.

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

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Please See Continuation of Second Sheet.	

[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	Date of mailing of the international search report
13 SEPTEMBER 2000	14 NOV 2000
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer RAMNANDA SINGH Telephone No. (703) 306-5631

Form PCT/ISA/210 (second sheet) (July 1998) ★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/18329

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, P ------- Y, P	US 5,974,139 A (MCNAMARA et al) 26 October 1999, figure 5; column 4, lines 62-67; column 5, lines 1-3; column 8, lines 7-51; column 10, lines 30-43.	1, 5-7, 11-13, 17-18, 21-22, 25, 28 ---------- 2,9,15,19, 23,26,29, 3,10,16, 20,24,27, 30
Y	US 4,656,451 A (POMPONIO) 07 April 1987, figures 1-8; column 3, lines 12-68; column 4, lines 1-68; column 5, lines 1-14.	2,9,15,19,23, 26,29
Y	US 5,581,434 A (LANDLER) 03 December 1996, figure 1; column 1, lines 18-35; column 2 , lines 27-35; column3, lines 19-67; column 4, lines 1-53.	3, 10, 16, 20, 24, 27, 30
A	BUDAK, ARAM; Passive and Active Network Analysis and Synthesis; Houghton Mufflin Company, New Jersey, 1974, Chapters 3 (pp. 71-80); 4 (pp. 86-111); and 18 (pp. 533-552).	4,8,14

B. FIELDS SEARCHED
Documentation other than minimum documentation that are included in the fields searched:

BUDAK, Aram; Passive and Active Network Analysis and Synthesis; Houghton Mufflin Company, New Jersey, 1974, Chapters 3, 4, 17 and 18.
OPPENHEIM, Alan et al , Digital Signal Processing, Prentice Hall, New Jersey, 1975, Chapter 5.

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

US Patents Full Text Database
JPO Abstracts Database
EPO Abstracts Database
Derwent World Patents Index
IBM Technical Disclosure Bulletins

Search Terms: Transient voltage suppressor$2; POTS device$2; Telephones; ferrite bead$2; noise suppressor$2