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TELEPHONE LINE STATUS MONITOR5 **Field of the invention**

The invention relates to a device to monitor the status of a telephone line in real time.

10 **Background of the invention**

As the telephone industry has changed in recent times, it has become common for customers of telephony services to use more of their own equipment and to do a greater amount of their own wiring instead of relying on the telephone
15 company. There exists a need for devices which can aid and assist the relatively unskilled and unprofessional people in recognizing problems which can affect their telephone services. Telephone line status monitors are useful where telephone users install their own telephone networks to provide their services, such as internet service providers (ISP), Banks for point of sale (POS) or
20 automatic teller machine (ATM) services, tele-marketing companies or other companies that use multiple telephone lines in relation to the provision of their services. These companies predominantly use hunting systems to manage their telephone lines for incoming calls, but if there is a fault in one or some of these telephone lines, the operator cannot know which line was faulty and also, they
25 would not know there is a fault until they get complaints from customers.

Usually, if users of telephone lines have many lines and they have problems with their lines, they have to check the entire network of telephone lines one by one to find the faulty one. It is therefore very inconvenient to discover where the fault
30 lies. It would be advantageous if the users could identify the source of the problem and correct it, or at least be able to identify those areas which may be

responsible for causing the fault and to determine a suitable procedure in order to correct the fault.

For example, US Patent No. 4,544,807 teaches a portable fault detector test instrument which tests whether there is a fault in a telephone line. However, such an instrument may only test one telephone line at a time. It is not suitable for monitoring a number of telephone lines simultaneously nor is it suitable for permanent installation to monitor a number of telephone lines. Furthermore, a user would still have to have some technical know-how to make the appropriate electrical connections when a fault is suspected.

Summary of the invention

To reduce the difficulty to the user of identifying a faulty line, the invention may provide a device for monitoring multiple telephone lines in real time, so that if any of the telephone lines are faulty, the attention of an operator may be drawn to the fault.

A telephone line monitor according to the present invention may carry out measurements required to obtain the status of multiple telephone lines automatically. Therefore, the invention may provide an automatic open circuit fault detector for telephone lines that can be used by a relatively unskilled operator.

According to one aspect of the invention, there is provided a telephone line status monitoring device for monitoring a plurality of telephone lines simultaneously including one or more line status monitors in connection with the telephone lines to monitor the status of each telephone line; at least one line status controller associated with one or more line status monitors to control the monitoring of each telephone line by the line status monitors; wherein said monitoring device

automatically identifies a fault in any one of the plurality of telephone lines and generates a signal to indicate the fault in that telephone line.

5 It is preferable that the device includes a voltage level detector associated with the line status monitor to monitor the voltage level in each telephone line such that a fault is detected when the voltage level falls below a pre-determined voltage reference. As the normal voltage level in telephone lines may vary, the device preferably includes a line reference level adjuster to pre-set the pre-determined voltage reference corresponding to the normal operating voltage
10 condition of the telephone line.

Preferably, the voltage level detector generates an output, and the device includes a status decoder to decode the output from the voltage level detector. Further, the device may include a ring eliminator circuit to eliminate unnecessary
15 voltage disturbance when the telephone line is ringing.

It is also preferable that the device includes a data bus system associated with the output of said decoder to transmit data from the line status monitor to the line status controller.
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Besides being stand-alone, it is preferable that the device is connectable to a computer host for providing a data-logging functionality. In that case, the device may include a central processor operatively connected to the line status controller and a database associated with the central processor, so that the
25 central processor issues commands to the line status monitor to check the status of each line, and stores the result of the line status check in the database.

In one particular embodiment, the one or more line status monitors and the at least one line status controller are located in an enclosure and are arranged
30 adjacent to one another. Other embodiments are also possible.

The device preferably includes a protective circuit to prevent circuit damage when removing the line status controller without switching off the power supply to the device. It is also preferable that the device provides signal indications of whether the telephone is on-hook or off-hook. The device may also be designed to activate an alarm if there is a fault located in one or more telephone lines.

Preferably, the device includes an RS-485 to RS-232 converter between the central processor and the line status controller.

It will be convenient to hereinafter describe an embodiment of the present invention with reference to the accompanying drawings which illustrate one form of telephone line monitoring device and system incorporating the invention. It is to be understood that the particularity of the drawings and the related description is not to be understood as superseding the generality of the broad description of the invention as defined in the claims.

Brief Description of the Drawings

The drawings illustrate a preferred embodiment of the invention.

Figure 1 shows the line status monitor in a one rack shelf device according to the preferred embodiment of the invention.

Figure 2 shows a block diagram of the relationships between the various components of the line status monitoring system according to the preferred embodiment of the invention.

Figure 3 shows a block diagram explaining the operation of the Line Status Monitor Controller (LCM) card;

Figure 4 shows block diagrams explaining the operation of the Line Status Monitor Module (LSM) card;

5 Figures 5a through to 5f shows the flowcharts covering the operation of the LCM firmware;

Figure 6a shows a schematic circuit diagram of the telephone line interface circuit part of the LSM card;

10 Figure 6b shows a schematic circuit diagram of the Level Status Detector circuit included in the LSM card;

Figure 6c shows a schematic circuit diagram of the Status Decoder circuit included in the LSM card;

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Figure 6d shows a schematic circuit diagram of the LED display and the driver circuit part of the LSM card;

20 Figure 6e shows a schematic circuit diagram of the Ring eliminator circuit part of the LSM card;

Figure 6f shows a schematic circuit diagram of the power on delay circuit part of the LSM card;

25 Detailed Description of the preferred embodiment of the invention

Figure 1 shows the line status monitor in a one rack shelf device. Essentially, the monitoring system in this embodiment includes a 19-inch rack shelf 10. Each rack shelf consists of sixteen line status monitor module cards (LSM cards) 12, the module that is used to monitor the telephone lines. There is a line status monitor controller card (LCM Card) 14, to control the sixteen LSM cards 12 in the

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rack shelf 10 monitoring the telephone lines in the rack 10. In this particular embodiment, each rack shelf 10 consists of one LCM card 14 and sixteen LSM cards 12 so one racking sub-system (comprised in one rack shelf) can monitor 32 telephone lines either in a stand along or data-logging mode. Other configurations can also be envisaged. More than one rack shelf can be included in the system.

Figure 2 shows a block diagram of the relationships between the various components of the line status monitoring system 16 according to the preferred embodiment of the invention. Preferably, in a data-logging mode, a personal computer is included in the system 16 as a computer host 18. The system 16 can operate in a stand-alone mode or a data-logging mode. Each LSM card 12 is connected to at least one telephone line. The LSM cards 12 are in turn connected by an Internal Data Bus 22 to LCM cards 14 as discussed above. The LSM cards 12, LCM card 14 and Internal Data Bus 22 are preferably contained in a rack shelf. In turn, each LCM card 14 is communicably linked to the computer host 18 via an I/O Data Bus 24.

In the data-logging mode, the computer host 18 comprising a central processor and preferably a database, gives a command sequentially to the entire monitoring system 16 to sample the status of all telephone lines which are connected to the system 16. Each LSM card 12 of the system 16 receives the command and interprets it, then executes the command. The result of the command will then be recorded in the database by the computer host 18. The computer host 18 may produce a report according to a pre-determined time interval or according to the specific device, as desired by the user.

In the stand-alone mode, each of the rack shelves 10 can operate as a stand-alone device without the computer host 18. Each rack shelf monitors 32 telephone lines. In this mode the user can use as many rack shelves as needed depending on how many telephone lines are to be monitored.

On the other hand, in the data-logging mode, the system needs a personal computer as a computer host. This personal computer is needed for data logging and managing of data from an entire sixteen-rack shelf. The lines to be monitored in this mode can be limited to up to 512 lines. Using data from the entire rack shelf, the user can create a statistic, for example, of the most faulty line in a certain time interval or a busy time in a day.

This system 16 uses primarily two types of indicators to indicate the telephone line status, three light emitting diodes (LED) in the LSM to indicate On Hook, Off Hook and alarm status. Other indicators are also possible. The other is an indicator in the PC Monitor (PC Software). Besides the LEDs on the LSM card, there is a red colour LED and buzzer on the LCM card to indicate the alarm status.

Figure 3 shows a block diagram explaining the operation of LCM card 14. The processor of LCM card 14 comprises a Micro-controller 24, such as the micro-controller model 89C52, as a Central processing unit. Micro-controller 24 interprets commands from the computer host 18 and checks the telephone lines through LSM cards 12. LCM card 14 also includes a low address buffer 25, RTCC 27, push button switch 29a as an alarm reset, buzzer 29b and red colour light emitting diode 29c to indicate if one of the lines is faulty. There is also preferably a dip-switch 29d to pre-set an address to set the valid address on the memory map address of the micro-controller 24. LCM card 14 also has a converter 26 from an RS-232 signal to RS-485, because in this embodiment, the communication between the host computer 18 to the LCM card is using an RS-485 interface and the micro-controller 24 does not have an RS-485 port. RS-485 converter 26 converts the RS-232 port of micro-controller 24 to an RS-485 signal. A protective circuit in the form of a power on delay circuit 28 is included to prevent circuit damage when LCM card 14 is lifted from rack 10 whilst the power supply is still on.

With reference to Figure 4, the following is a detailed description of the monitoring of telephone line status through telephone line interface 30. The monitoring by LSM card 12 is done by detecting and monitoring voltage level of the telephone line using a voltage level status detector 32 and this is done by a parallel arrangement. The parallel arrangement is preferred because the difference between On Hook and Off Hook voltage levels is relatively high. For example, the On Hook level is between 48 to 52 volts and the Off Hook level is between 8 to 11 volts. When there is an open circuit, the level is almost zero volts but if the open circuit is on the positive wire, the negative wire will be measured with reference to ground.

Upon passing through level status detector 32, an output is sent to a status decoder 34 which decodes the voltage level, and relays it to data bus driver 35 and associated data bus. LED Display 36 is activated according to the status of the telephone line. An address decoder 37 reads an address given by computer host 18 from the address bus and compares it to a preset address before sending it to data bus driver 35.

For this purpose, the circuit uses two level detectors, an On Hook detector and Off Hook detector using an operational amplifier. Output from these detectors enter status decoder 34 which will decode the telephone line status, ie whether it is On Hook, Off Hook or Open Circuit (in which case the alarm is activated). These results may be indicated by a light emitting diode via an LED driver, for example, green for On Hook, yellow for Off Hook and red for alarm. Parallel with that, the output of the decoder also enters the Data Bus system via a data bus driver 35 and is dependent on the address decoder, which is set on a preset address, whether the address is valid or not.

In anticipation of different telephone line voltage levels in different countries, there is a line reference level adjustor associated with level status detector 32 to define normal voltage level conditions of the telephone line.

- 5 To avoid disturbance of line voltage detection whenever the line is ringing, there is a ring eliminator circuit 38 to eliminate the ringing signal. For transmitting and receiving data between the LCM card 14 and LSM card 12, an internal bus of the micro-controller 24 is used. To prevent damage to this card whenever the card is hot-swapped from the rack shelf, there is a power on delay circuit 28 in each of
10 the LCM cards.

- Figures 5a through to 5f shows flowcharts of the firmware associated with LCM card 14. Generally, the system 16 obtains line status for each line sequentially (figures 5d, 5e & 5f). The system 16 also tests whether any operative keys, such
15 as the reset key 29a and alarm buzzers 29b are pressed. Thereafter, the system 16 sends the status of each line to the computer host (figure 5c).

- With reference to Figure 6a, which is a schematic circuit diagram of the telephone line interface circuit 30 of LSM card 12, diode bridge 40 in this circuit is
20 used as a polarity guard and to ensure that the polarity of the signal that enters the circuit has the right polarity. Otherwise, if the polarity is reversed, damage may be done to the circuit. The signal from diode bridge 40 is divided by ten to obtain a level that can fit within the range of level status detector circuit 32. It is also to prevent the signal from being too high when the telephone line is ringing,
25 because the voltage level of the signal rises to up to 70 volts.

- The function of differential input amplifier 42 in Figure 6a is to isolate the telephone line network of the telephone company from signal interference arising from the system circuit because this system is using its own power supply.

Figure 6b shows a schematic circuit diagram of the Level Status Detector circuit 32 of LSM card 12; Figure 6c shows a schematic circuit diagram of the Status Decoder circuit 34 of LSM card 12; Figure 6d shows a schematic circuit diagram of the LED display 36 and the driver circuit of LSM card 12; Figure 6e shows a schematic circuit diagram of the Ring eliminator circuit 38 of LSM card 12; and Figure 6f shows a schematic circuit diagram of the power on delay circuit 28 of LSM card 12.

It will be appreciated that by monitoring the telephone line at that point where the user has responsibility, the telephone line status monitor can be employed to determine and correct any line faults. The device is preferably wired to a distribution panel or single line circuit.

For indication of fault on output, the light emitting diodes are employed to provide visual display. The computer host also provides visual display by way of an attached monitor screen.

Finally, while a particular embodiment of the invention has been shown and described, it will be appreciated by those skilled in the art that changes and modifications of the present invention may be made without departing from the invention in its broader aspects. As such, the scope of the invention should not be limited by the particular embodiment and specific construction described herein but should be defined by the appended claims and equivalents thereof. Accordingly, the aim in the appended claims is to cover all such changes and modifications as fall within the spirit and scope of the invention.

**CLAIMS:**

- 5 1. A telephone line status monitoring device for monitoring a plurality of telephone lines simultaneously including :
- one or more line status monitors in connection with the telephone lines to monitor the status of each telephone line;
 - at least one line status controller associated with one or more line status monitors to control the monitoring of each telephone line by
- 10 the line status monitors;
- wherein said monitoring device automatically identifies a fault in any one of the plurality of telephone lines and generates a signal to indicate the fault in that telephone line.
- 15 2. A telephone line status monitoring device according to claim 1, wherein the device includes a voltage level detector associated with the line status monitor to monitor the voltage level in each telephone line such that a fault is detected when the voltage level falls below a pre-determined voltage
- 20 reference.
3. A telephone line status monitoring device according to claim 2, which includes a line reference level adjuster to pre-set the pre-determined voltage reference corresponding to a normal operating voltage condition of
- 25 the telephone line.
4. A telephone line status monitoring device according to claim 2 or 3, wherein the voltage level detector generates an output, and the device includes a status decoder to decode the output from the voltage level
- 30 detector.



5. A telephone line status monitoring device according to any one of claims 2 to 4, which includes a ring eliminator circuit to eliminate unnecessary voltage disturbance when the telephone line is ringing.
- 5 6. A telephone line status monitoring device according to claim 4, wherein the device includes a data bus system associated with the output of said decoder to transmit data from the line status monitor to the line status controller.
- 10 7. A telephone line status monitoring device according to any one of the preceding claims which includes a central processor operatively connected to the line status controller and a database associated with the central processor, so that the central processor issues commands to the line status monitor to check the status of each line, and stores the result of
15 the line status check in the database.
8. A telephone line status monitoring device according to any one of the preceding claims, wherein the one or more line status monitors and the at least one line status controller are located in an enclosure and are
20 arranged adjacent to one another.
9. A telephone line status monitoring device according to any one of the preceding claims, which includes a protective circuit to prevent circuit damage when removing the line status controller without switching off
25 power supply to the device.
10. A telephone line status monitoring device according to any one of the preceding claims, which provides signal indications of whether the telephone is on-hook or off-hook.



11. A telephone line status monitoring device according to claim 14, wherein the device activates an alarm if there is a fault located in one or more telephone lines.
- 5 12. A telephone line status monitoring device according to any one of the preceding claims, which includes an RS-485 to RS-232 converter between the central processor and the line status controller.