

**Apparatus for detecting a busy signal on a telephone line** ✓1005's  
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The present invention relates to apparatus for the detection of a busy signal on a telephone line.

When a first telephone subscriber attempts to reach a second telephone subscriber who is either engaged or has accidentally placed the telephone receiver in an off-hook position, busy signals will be generated by the telephone exchange and reported to the first telephone subscriber. The first telephone subscriber will also receive busy signals from the telephone exchange in the event that a leakage path exists between the telephone line conductors connected to the second subscriber's telephone instrument. Telephone exchanges or telephone central offices are unable to differentiate between a condition when a current leakage along the telephone line conductors connected to the subscriber's telephone instrument has caused a voltage drop from the on-hook telephone line voltage to a voltage equivalent to the off-hook telephone line voltage, and a true telephone receiver-off-hook condition.

When the second telephone subscriber has accidentally placed the telephone receiver in an off-hook position or when a leakage between the telephone line conductors connected to the subscriber's telephone instrument has occurred, the same busy signals will be generated by the telephone exchange and can be detected on the telephone line of said telephone subscriber.

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The busy signals comprise tones or audio frequency signals which are alternately turned on and off by the telephone exchange for specific durations. For example, a busy signal can comprise of 400 Hz sinusoidal signals (when it originates from an analog telephone exchange) or 425 Hz sinusoidal signals (when it originates from a digital telephone exchange), known as tones hereinafter, alternately turned on and off by the exchange for durations of 0.75 seconds each.

Proposals which serve to detect telephone line conditions including the telephone receiver-off-hook condition have been proposed but they do not specifically indicate directly to the telephone line subscriber one of several possible conditions that would require corrective action. These possibilities include the telephone receiver-off-hook-and-not-in-use condition and a leakage occurring at the point of connection between the telephone line and telephone instrument, or in the telephone instrument. When such conditions remain undetected and corresponding corrective action is not taken, these conditions may prevent a third party from making successful attempts to reach the subscriber.

It is an object of the invention to provide an improved apparatus for detecting a busy signal on a telephone line.

In accordance with the first aspect of the present invention, there is provided an apparatus connectable to the subscriber end of a telephone line comprising a means for detecting a busy signal on a telephone line and for comparing a duration of the busy

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signal to a pre-determined duration and for generating an alarm signal when the duration exceeds the pre-determined duration, and an alarm actuatable in response to the alarm signal.

The first aspect of the invention is based on the realisation by the inventor that busy signals on a telephone line deriving from a subscriber dialing an engaged number and busy signals indicating a condition requiring correction action may be distinguished in most cases by the duration of the busy signal, since if a subscriber dials an engaged number, the subscriber will replace the telephone handset after only a few seconds.

Preferably, the busy signal detecting means comprises a phase lock loop means for detecting a standard tone of a busy signal and generating a logic output indicating presence or absence of the tone. It is also preferred that the alarm comprises at least one of an audible or visual indicator.

In accordance with the second aspect of the present invention, there is provided an apparatus connectable to the subscriber end of a telephone line for detection of a busy signal on a telephone line comprising a power supply circuit, an alarm circuit for generating an alarm signal in response to said busy signal, a power circuit including means for detecting a telephone line off-hook condition and for supplying power to the alarm circuit in response to said detection.

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The second aspect of the invention allows the apparatus to be self powered and to power up only when it is necessary for operation.

Preferably, the power supply circuit comprises a linear voltage regulator for providing regulated DC voltage supply, and a pair of MOSFETs configured as a source current switch for the micropower linear voltage regulator.

In accordance with the third aspect of the present invention, there is provided an apparatus connectable to the subscriber end of a telephone line comprising a tone detector, a controller responsive to the tone detector for identifying a detected tone as a busy signal, comparing the duration of the busy signal to a pre-determined duration and generating an alarm signal when the duration of the busy signal exceeds the pre-determined duration, an alarm actuable in response to the alarm signal, and a power supply circuit including means for detecting a telephone line off hook condition and for supplying power to the detector, controller and alarm in response to said detection.

A preferred embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which :

Figure 1 is a block diagram of the preferred embodiment of the invention.

Figure 2 is a flow chart of the controller algorithm of the embodiment of Figure 1.



A preferred embodiment of apparatus for detecting a busy signal on a telephone line is illustrated in Figure 1 and comprises a bridge rectifier 4, the rectifier being placed in parallel with telephone instrument 1 connected to the TIP and RING telephone lines 2 and 3, an AC decoupler 13, a telephone line DC voltage level detecting circuit 5, a DC voltage regulator 6, a switching circuit 7 placed in series with the current return path of the DC voltage regulator 6, a DC decoupler 12, a telephone line tone detector 8, a supply switching circuit 9 placed in series with the power supply path to the telephone line tone detector 8, a controller 10, and a fault indicator 19.

The apparatus performs a first function to derive a DC voltage from the telephone line to provide electrical power to the apparatus upon detection of telephone receiver-off-hook condition, a second function to detect tones on the telephone line connected to the telephone instrument, and a third function to determine telephone receiver-off-hook-and-not-in-use condition (or a leakage occurring at the connection between the telephone line and the telephone instrument, or in the telephone instrument) and indicate to the telephone subscriber by an alarm.

Referring to the first function of the described embodiment of the present invention to derive a DC voltage from the telephone line to provide electrical power to the apparatus upon detection of telephone receiver-off-hook condition, the telephone line DC voltage level detecting circuit 5, DC voltage regulator 6 and switching circuit 7 will be described with reference to an operation to switch the power supply when the telephone receiver-on-hook and off-hook conditions are detected.

As shown in Figure 1, the bridge rectifier 4 will appear in parallel with the TIP 2 and RING 3 wires of the telephone line. In such an electrical arrangement, the DC voltage measured at node 14 will always be positive with reference to line 15, thus providing an electrical reference ground independent of the polarities of the TIP 2 and RING 3 conductors which are controlled by the telephone exchange. The DC voltage level at node 14 will fluctuate due to the various on-hook and off-hook conditions of the telephone line, and this will be detected by the telephone line DC voltage level detecting circuit 5. Typically, the on-hook telephone line voltage is greater than 30 V (usually measured at 44 V) while the off-hook telephone line voltage is less than 20 V (usually measured at 10 V, although the current consumption of the connected telephone instrument may cause the voltage to vary).

The telephone line DC voltage level detecting circuit 5, which for example includes a low voltage sensing chip, preferably ICL MC34164, will have a first DC voltage level threshold set at 30 V and a second DC voltage level threshold set at 20 V. Upon sensing a voltage change at node 14 that has resulted in the voltage level crossing the first and second DC voltage level thresholds consecutively, a change from on-hook condition to off-hook condition is detected. Alternatively, a voltage change that has resulted in the voltage level crossing the second DC voltage level threshold, and then the first DC voltage level threshold, means that a change from off-hook condition to on-hook condition has occurred.

Upon detecting a change from on-hook condition to off-hook condition, the telephone line DC voltage level detecting circuit 5 will consequently change the state of a control signal on line 18 to switching circuit 7. Switching circuit 7, which for example comprises a pair of MOSFETs arranged in a configuration that functions as a current switch, is connected in series with the current return path of the DC voltage regulator 6, ie, the connection between line 15 and the reference ground of the DC voltage regulator 6. In the case that the DC voltage level at node 14 is greater than 30 V, or the telephone instrument is on-hook, switching circuit 7 will remain in a non-conducting state due to a first control signal on line 18. This means that the DC voltage regulator 6, which for example comprises a micropower linear voltage regulator, preferably ICL7663, is not referenced, or is floating, because the source current drawn from node 14 via AC decoupler 13 cannot be returned to line 15. The DC voltage regulator 6 is therefore functionally disabled and cannot provide a regulated supply, via supply rail 16, to power the other functional circuitries of the apparatus described hereinabove. In the event that the DC voltage level at node 14 is less than 20 V, or the telephone instrument is off-hook, switching circuit 7 will remain in a conducting state due to a second control signal on line 18. A regulated voltage supply would then be readily available on supply rail 16 to power the telephone line tone detector 8 and controller 10.

Referring to the second function of the described embodiment of the present invention to detect tones on the telephone line connected to the telephone instrument, the mode of operation of telephone line tone detector 8 will be described hereunder. The telephone line tone detector 8 and controller 10 will be activated by the power-up action,

ie, by way of receiving electrical power via the supply rail 16 from DC voltage regulator 6 upon detection of telephone receiver-off-hook condition. In the telephone receiver-off-hook condition, the telephone line tone detector 8, which comprises a phase lock loop device, will read off-hook AC signals from the telephone line via bridge rectifier 4 and DC decoupler 12. Using known phase lock loop techniques, the telephone line tone detector 8 is preset to detect standard tone frequencies of busy signals, and will test telephone receiver-off-hook AC signals and report to controller 10 the presence of any tones. Since busy signals consist of tones alternately turned on and off for specific durations, the telephone line tone detector 8 will therefore output data consisting of logic 0s (tones present) and logic 1s (tones not present) with corresponding timing conditions via line 17 to controller 10. In the event that busy signals are reported by the telephone exchange and controller 10 has successfully determined that the condition is telephone receiver-off-hook-and-not-in-use (or a leakage occurring at the connection between the telephone line and the telephone instrument, or in the telephone instrument), the telephone line tone detector 8 will subsequently be deactivated by controller 10 by the power-down action, ie, the switching of the supply switching circuit 9 to non-conducting state, to minimise the total current consumption of the apparatus.

Referring to the third function of the described embodiment of the present invention to determine receiver-off-hook-and-not-in-use condition (or a leakage occurring at the connection between the telephone line and the telephone instrument, or in the telephone instrument) and indicate to the telephone subscriber by an alarm, controller 10 is described hereunder with the aid of a flow chart as illustrated in Figure 2. The

following are examples of telephone receiver-off-hook conditions that can cause the power-up of controller 10, wherein:

- 1) telephone subscriber dials out and engages other party, or vice versa, and communicates,
- 2) telephone subscriber dials out and receives busy signals from the telephone exchange,
- 3) telephone subscriber accidentally or deliberately places the receiver in a continual off-hook position,
- 4) telephone subscriber accidentally or deliberately places the receiver in a continual off-hook position and the handset picks up high levels of background noise,
- 5) current leakage occurring at connection between the telephone line and the telephone instrument 1,
- 6) current leakage occurring in telephone instrument 1.

Controller 10, comprising a microcontroller with embedded proprietary program codes, will perform tasks to test the telephone line and the connected telephone instrument 1, and will indicate to the telephone subscriber by an alarm if any one of the telephone receiver-off-hook conditions 3 to 6 is true. Telephone receiver-off-hook conditions 3, 4, 5 and 6 are known as telephone-receiver-off-hook-and-not-in-use conditions, while telephone receiver-off-hook conditions 1 and 2 are known as telephone receiver-off-hook-and-in-use conditions.

Controller 10 will begin the operation immediately after power-up by reading the standards, preferably set via hardware jumpers or switches connected to controller 10, at state 30. This is to enable controller 10 to be configured with the local requirements such as the tone turned-on and turned-off durations, or corresponding logic 0 and 1 timing conditions, of busy signals generated by the corresponding local telephone exchanges or telephone central offices. Controller 10 will then enter state 31 to test the logic status of line 17 on a frequent basis and at a predetermined sampling rate, during any telephone receiver-off-hook condition via a logic monitoring means. After each sampling at state 31, controller 10 will enter state 32, which is a busy signal monitoring means, on condition that a tone is detected by the telephone line tone detector 8 and a corresponding logic 0 is read on line 17. Alternatively, controller 10 will enter state 33 on condition that a tone is absent from the telephone line and a corresponding logic 1 is read on line 17.

By way of an example of a typical telephone receiver-off-hook condition wherein telephone subscriber dials out and engages other party, or receives busy signals from telephone exchange, further description on the operations of controller 10 will be provided hereunder.

When the telephone subscriber lifts the handset to dial out to another party, a dial tone is initially detected on the telephone line. In some countries, telephone exchanges or telephone central offices report dial tones which consist of continuously occurring audio frequency signals similar in frequency to that of tones found in busy signals. In such

situations, the telephone line tone detector 8 will report a logic 0, for as long as the dial tone exists, to controller 10 at state 31 via line 17. Controller 10, via logic monitoring means at state 31, samples line 17 frequently at a predetermined rate which is higher than the rate of occurrence of alternating durations of logic 0s and logic 1s constituting a busy signal. Therefore, unless sufficient samples of logic 0s and logic 1s are received by controller 10 in state 32 according to the pattern as prescribed by the hardware settings read at state 30 to form a single busy signal period, for example a logic 0 and a logic 1 occurring on line 17 for 0.75 seconds each, controller 10 at state 32 will always return to state 31. Since a sustained logic 0 is detected for the duration of the dial tone, controller 10 will enter into a loop between state 31, state 32 and state 31 subsequently upon each sampling for the same duration. Such a loop is known as logic 0 loop hereinafter.

When subsequent dialing signals are detected on the telephone line connected to telephone instrument 1, i.e. using either DTMF or other signaling format, telephone line tone detector 8 will constantly hold line 17 at logic 1 status. This means that tones are not present and controller 10 will subsequently enter into a loop between state 31, state 33, state 32 and state 31 each time a sample is taken by controller 10 at state 31, known as logic 1 loop hereinafter. For as long as busy signals have not been detected and counted by controller 10 since the power-up initialisation, controller 10 will continue to enter into the logic 1 loop.

Upon the telephone subscriber's successful attempt to reach the desired party after dialing, the telephone subscriber will continue to communicate with the desired party. Since tones are absent during the communication, controller 10 will therefore enter into the logic 1 loop continuously until such a time when the telephone subscriber terminates the communication by placing the handset on-hook.

However, upon the telephone subscriber's unsuccessful attempt to engage the desired party and a busy signal is received from the telephone line, controller 10 will subsequently alternate between logic 0 loops and logic 1 loops for durations according to the corresponding durations of logic 0 and logic 1 on line 17. If sufficient samples (or loops thereof) of logic 0s and logic 1s are recorded by controller 10 in state 32 according to the prescribed pattern to make up a period of a busy signal, a true condition will then be registered. Controller 10 will then enter state 34 where a counter is activated and the resulting counter value stored. The stored counter value will therefore reflect the number of periods of busy signals detected since initialisation and will subsequently be compared to a first value as controller 10 enters state 35. The first value is preset to represent the number of periods of busy signals required to indicate a telephone receiver-off-hook-and-not-in-use condition, and takes into account parameters such as the typical time required for a telephone subscriber to place the handset back on-hook after an unsuccessful attempt to dial out and subsequent busy signals are heard. Therefore, in the event that the telephone subscriber places the handset on-hook before the stored counter value reaches the first value, controller 10 will be deactivated before a true condition can occur for state 35. During telephone

receiver-on-hook condition, controller 10 will not be supplied with power and therefore will be reset to an initial state upon the next power-up.

If the telephone subscriber accidentally or deliberately places the handset off-hook, sufficient counts of periods of busy signals will be recorded and this will result in controller 10, from state 35, entering state 38 on condition that the stored counter value from state 34 has reached the first value. Controller 10 will then trigger fault indicator 19, which for example can be an alarm consisting of a visual indication such as a blinking lamp and an audible indication such as a buzzer, while continuously looping in state 38.

In the event that the handset picks up high levels of background noise while in the off-hook position as mentioned in telephone receiver-off-hook condition 4, an incoherent busy signal may be read from the telephone line which may be undetectable at the telephone line tone detector 8 at times. However, in such a circumstance it is impossible for controller 10 to tell if there is a genuine fault or telephone receiver-off-hook-and-not-in-use condition, since the noise may mask the busy signal. This may cause an inadvertent delay in the counting up of the stored counter value at state 34 to reach the first value in state 35. To prevent such a delay from causing a corresponding delay in triggering fault indicator 19, controller 10, while in state 33, will always check if busy signals were previously detected and counted in state 34 and if so, compare the stored counter value to a preset second value. If the stored counter value concurs with the second value, controller 10 will enter state 36 where a countdown timer is activated

and counting of a timer value initiated. Upon timeout at state 37, controller 10 will enter state 38 (and therefore continue to loop in state 38) to activate the alarm. If, in the meantime, the subscriber has replaced the handset before the counter at state 36 has timed out, power to the controller 10 will be cut and the alarm will not be activated.

When a current leakage occurs at the connection between the telephone line and telephone instrument 1, or in telephone instrument 1, the telephone exchange will report standard busy signals on the telephone line even when the handset is placed in an on-hook position. As such the apparatus will be able to detect the busy signals and determine a telephone receiver-off-hook-and-not-in-use condition on the telephone line, via the operations described hereinabove.

The embodiments of the invention are not to be construed as limitative. For example, switching circuit 7 may be placed in series with the current source of the DC voltage regulator 6, ie, the source current path from node 14, via AC decoupler 13, to the input voltage connection of the DC voltage regulator 6.



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### Claims

1. Apparatus connectable to the subscriber end of a telephone line comprising:  
means for detecting a busy signal on a telephone line and for comparing a duration of the busy signal to a pre-determined duration and for generating an alarm signal when the duration exceeds the pre-determined duration; and  
an alarm actuatable in response to the alarm signal.
2. Apparatus as claimed in claim 1 further comprising means for detecting a telephone off-hook state.
3. Apparatus as claimed in claim 2 wherein the telephone off-hook state detecting means comprises means for sensing a voltage on a telephone line indicative of the telephone off-hook state.
4. Apparatus as claimed in claim 3 wherein the sensing means comprises a voltage sensor.
5. Apparatus as claimed in any one of claims 2 to 4 further comprising power supply means for supplying power to the busy signal detecting means in response to said telephone off-hook state.
6. Apparatus as claimed in any one of the preceding claims wherein the busy signal detecting means comprises phase lock loop means for detecting a standard tone

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of a busy signal and generating a logic output indicating presence or absence of the tone.

7. Apparatus as claimed in claim 6 wherein the busy signal detecting means further comprises means for monitoring said logic signal and comparing the logic signal with a prescribed logic pattern indicative of a busy signal period and a counter for counting busy signal periods and generating an alarm signal when the number of periods exceeds a number indicative of said pre-determined duration.
8. Apparatus as claimed in claim 7 wherein the busy signal detector means further comprises a count down timer for providing an alarm signal in response to a time-out after the busy signal had been detected.
9. Apparatus as claimed in any one of the preceding claims wherein the alarm comprises at least one of an audible or visual indicator.
10. Apparatus connectable to the subscriber end of a telephone line for detection of a busy signal on a telephone line comprising:  
a power supply circuit,  
an alarm circuit for generating an alarm signal in response to said busy signal,  
a power circuit including means for detecting a telephone line off-hook condition and for supplying power to the alarm circuit in response to said detection.

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11. Apparatus as claimed in claim 10 wherein the power supply circuit comprises a linear voltage regulator for providing regulated DC voltage supply.
12. Apparatus as claimed in claim 10 or claim 11 wherein the power supply circuit comprises a pair of MOSFETs configured as a source current switch for said regulator.
13. Apparatus connectable to the subscriber end of a telephone line comprising:
  - a tone detector;
  - a controller responsive to the tone detector for identifying a detected tone as a busy signal, comparing the duration of the busy signal to a pre-determined duration and generating an alarm signal when the duration of the busy signal exceeds the pre-determined duration;
  - an alarm actuable in response to the alarm signal; and
  - a power supply circuit including means for detecting a telephone line off hook condition and for supplying power to the detector, controller and alarm in response to said detection.

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