

A SPEECH AMPLIFIER ASSOCIATED WITH AN LED

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a speech transmit amplifier provided with a light emitting diode (LED). It more specifically applies to the control of the LED inside such an integrated
5 amplifier in a telephone set.

2. Discussion of the Related Art

In a telephone set, an electroluminescent diode, or LED, is generally used for lighting the key-pad, or for indi-
10 cating a hold or dialling condition. Commonly, the telephone set does not comprise its own power supply but is fed by a line current of a telephone signal on the telephone line, this line current being also used for feeding the LED. The telephone signal comprises a DC component, provided by the telephone
15 exchange and sent on the telephone line to be used by the subscribers' telephone sets. The DC component of the telephone signal is variable as a function of the line length or other line parameters. The signal also comprises an AC component due to the modulation of the speech signal.

20 Conventionally, a predetermined fraction of the line current is used, inside the amplifier, to supply the LED. This fraction is usually about 25% of the line current. In such an

instance, as the line current varies as a function of the line characteristics, the LED illumination is not constant. Indeed, this illumination is low for long lines and very low for parallel connections. On the contrary, if the line is short, the
5 illumination is too strong and reduces the lifetime of the LED. Additionally, as the current oscillates about the DC component, the use of a fixed portion of the line current to control the LED causes the illumination to vary for a given line. Furthermore, the presence of the LED causes the transmitted signal to
10 be distorted for high negative swings of the speech signal. In some cases, a very small but fixed amount of the line current is also used to light up the LED. But this current cannot be large, otherwise it will upset the voltage-current characteristics of the line. Therefore, in such cases, the LED illumination is
15 poor.

SUMMARY OF THE INVENTION

It is an object of the invention to overcome the drawbacks of existing amplifiers with regard to LED control.

20 Another object of the invention is to provide a voice amplifier that feeds an LED with a constant current.

Another object of the invention is to avoid the distortion of the speech signal caused by the presence of an LED in the voice amplifier.

25 In one illustrative embodiment, the invention provides a telephone transmit amplifier for a telephone set that does not have its own power supply, comprising an LED having an anode connected to a first positive terminal of the telephone line and a circuit for determining a ratio between a line current and a
30 line voltage, a reference current generator for supplying the LED with a constant current, and a deriving circuit for deriving the current flowing in the LED when the voltage across the terminals of the line becomes lower than a predetermined value.

According to an embodiment of the invention, the transmit amplifier further comprises a first operational amplifier measuring the current in the LED and whose feed-back loop limits this current to a value determined by the reference
5 current generator.

According to an embodiment of the invention, a cathode of the LED is connected to the non-inverting input of the first amplifier.

According to an embodiment of the invention, the
10 reference current generator comprises a bipolar PNP transistor having an emitter connected to the first terminal of the line and a collector connected to the inverting input of said first amplifier.

According to an embodiment of the invention, the
15 deriving circuit comprises a transconductance amplifier whose feedback loop controls a switch that derives the current of the LED.

According to an embodiment of the invention, the switch comprises an NPN transistor whose collector is connected
20 to the first terminal of the line and whose emitter is connected, through a low value resistor, to the cathode of the LED.

According to an embodiment of the invention, the circuit for determining the ratio between the line current and the line voltage comprises a second operational amplifier whose
25 inverting input receives the speech signal to be transmitted, added to a DC component of the line voltage provided by a telephone exchange.

According to an embodiment of the invention, the feed-back loop of the second amplifier comprises two Darlington-
30 connected NPN transistors and two diodes, the collector of the second transistor being connected to the inverting input of the transconductance amplifier and the non-inverting input of the transconductance amplifier being connected to the anode of the second diode.

As the LED according to an embodiment of the invention is in series with the transmit amplifier, or speech circuit, the LED does not introduce any change in the current through the speech circuit.

5 As the LED according to an embodiment of the invention is supplied with a constant current, the telephone sets of various subscribers will have the same characteristics whatever be the line length. As the LED current is shunted when the voltage on the telephone line becomes too low, the presence of
10 the LED in the speech transmit amplifier does not distort the AC signals.

Thus, a speech transmit amplifier is obtained whose operation is not modified by the presence of a LED, while optimizing the operation of this LED.

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BRIEF DESCRIPTION OF THE DRAWINGS

Those objects, features and advantages, and others of the invention will be explained in detail in the following description of preferred embodiments made non-limitatively in
20 connection with the attached drawings wherein:

Fig. 1 is a block-diagram of a speech transmit amplifier associated with a LED according to the invention;

Fig. 2 schematically shows an embodiment of a speech transmit amplifier according to the invention;

25 Fig. 3 illustrates the current-voltage curve of the transmit amplifier according to the invention;

Fig. 4 illustrates the current in the LED as a function of the line current;

30 Figs. 5, 6, 7, and 8 are chronograms illustrating the potentials across the LED for various amplitudes of the speech signal; and

Fig. 9 illustrates a detailed implementation of the circuit of Fig. 2.

DETAILED DESCRIPTION

A feature of an embodiment of the present invention is that the LED is serial connected with the speech circuit.

Fig. 1 schematically shows the connections between an LED 1 and a transmit amplifier 11 according to an embodiment of the present invention.

The telephone line is symbolized by a generator 2 between two terminals A and B of the circuit, terminal B corresponding to the circuit ground. In fact, a bridge and a dial pulser (not shown) may be connected between the telephone line and terminals A and B.

The anode of LED 1 is connected to terminal A and the cathode of LED 1 is connected to a first terminal of transmit amplifier 11, a second terminal of transmit amplifier 11 being connected to terminal B.

According to an embodiment of the invention, speech transmit amplifier 11 comprises means for deriving the current flowing in LED 1. Such means comprise, for example, a NPN transistor T3 whose collector is connected to terminal A and whose emitter is connected, preferably through a low value resistor (not shown in figure 1), to the cathode of LED 1. Transistor T3 is controlled by amplifier 11 to shunt LED 1 when the voltage on the telephone line becomes lower than a predetermined value.

The speech transmit amplifier shown in Fig. 2 mainly comprises three feed-back loops. The first loop controls the ratio between the line current I_L and the line voltage V_L . The second loop measures the current I_{LED} flowing in the LED 1 and limits this current at a predetermined value. The third loop allows a suitable swing of the speech signal during the negative alternations, by deriving the current flowing in the LED 1.

The first loop may comprise a first operational amplifier A1 3. The non-inverting input of amplifier 3 is connected to a first positive terminal A of the circuit through

a voltage generator 4 and a resistor R1. The voltage generator 4 corresponds to two input terminals M+ and M- in the circuit which represents the amplified signal from the telephone microphone (not shown). The negative input terminal M- of the microphone signal is connected to the non-inverting input of amplifier 3 and the positive input terminal M+ is connected to resistor R1. The inverting input of amplifier 3 is connected to terminal A through a first polarization current generator 5. This inverting input is also connected to the anode of a diode D1 serially connected with a diode D2. The cathode of diode D2 is connected to the ground terminal B of the circuit through a resistor R5 and to the positive input terminal M+ of the microphone signal 4 through a resistor R2.

The feed-back loop of the operational amplifier 3 comprises the two diodes D1 and D2 and two NPN transistors T1, T2. The output of amplifier 3 is connected to the base of transistor T1, the collector of which is connected to terminal A. The emitter of transistor T1 is connected to the base of transistor T2 whose collector is connected to terminal A through a resistor R3 and LED 1. The emitter of transistor T2 is connected to the cathode of diode D2. A capacitor C2 for frequency compensation of the first loop is connected between the collector of transistor T1 and the base of transistor T2.

The second loop comprises a second operational amplifier A2 6. The non-inverting input of amplifier 6 is connected to the cathode of LED 1. The inverting input of amplifier 6 is connected to terminal A through a reference current generator 7 and to the collector of transistor T2 of the first loop through a resistor R4.

The feed-back loop of amplifier 6 comprises the resistor R4, a diode D3 and three bipolar transistors T3, T4, T5. The output of amplifier 6 is connected to the base of a PNP transistor T5 whose collector is connected to terminal B. The emitter of transistor T5 is connected to the cathode of diode D3, the

anode of which is connected to the base of the NPN transistor T4. The base of transistor T4 is also connected to terminal A through a second polarization current generator 8. The collector of transistor T4 is connected to terminal A and its emitter is
 5 connected to the base of the NPN transistor T3 whose collector is also connected to terminal A. The emitter of transistor T3 is connected to the collector of transistor T2 of the first loop and, through resistor R4, to the inverting input of amplifier 6. A capacitor C3 for frequency compensation of the second loop
 10 is connected between the base of transistor T5 and terminal A.

The third loop comprises a transconductance amplifier gm 9. The non-inverting input of amplifier 9 is connected to the anode of diode D2 of the first loop. The inverting input of amplifier 9 is connected to the collector of transistor T2 of
 15 the first loop.

The feed-back loop of the transconductance amplifier 9 comprises transistor T3 of the second loop and a PNP transistor T6. The output of amplifier 9 is connected to the base of transistor T6 whose emitter is connected to terminal A. The collector
 20 of transistor T6 is connected to the base of transistor T3, the emitter of transistor T3 being connected to the collector of transistor T2 and to the inverting input of amplifier 9. A resistor R6 serially connected with a capacitor C4 is connected between the output of amplifier 9 and its biasing input, so as
 25 to frequency compensate the third loop.

The circuit also comprises a positive temperature coefficient current source 10 between terminals B and M+.

For dynamic operation, the circuit also comprises capacitors. A capacitor C1 is connected in parallel with the
 30 current generator 10, its negative terminal being connected to terminal B. The capacitor C1 provides AC ground at terminal M+. A capacitor C5 serially connected with a resistor R7 is connected between terminals A and B. A capacitor C6 is connected between terminals A and B. Capacitors C5, C6 and resistor R7
 35 model the AC termination of the exchange.

Fig 3 shows the voltage-current characteristic curve between terminals A and B of the circuit shown in Figs. 1 and 2. This characteristic is determined by the first loop, that is by the current source 10, the operational amplifier 3, resistors 5 R1, R2, R5, diodes D1, D2 and transistors T1, T2.

The line voltage V_L is equal to the sum of the voltages across terminals R1, R2, R5. The voltage across R5 is equal to the product of the line current I_L by resistance R5. In the absence of speech signal between terminals M+ and M-, the 10 voltage across resistor R2 is equal to $2V_{be}$, where V_{be} represents the base-emitter voltage drop of a transistor (for example the voltage drop across each of the forward biased diodes D1 and D2). The voltage across resistor R1 is equal to the product of resistor R1 by the sum of the current I_{dc} provided by the source 15 10 and the current circulating in resistor R2. This current in resistor R2 is equal to $2V_{be}/R2$. Therefore, the relation between the line voltage V_L and the line current I_L can be written:

$$V_{L0} = I_L \cdot R5 + 2(1 + R1/R2)V_{be} + I_{dc} \cdot R1$$

This characteristic curve presents, from a value V_0 20 corresponding to $2(1 + R1/R2)V_{be} + I_{dc} \cdot R1$, a slope determined by resistance R5. The current source 10 compensates for variations of the value of the base-emitter voltages V_{be} as a function of the operating temperature. Therefore, V_0 is a temperature compensated reference voltage. At low currents, i.e. $I_L < I_{S1}$, V_0 25 is reduced by reducing I_{dc} gradually. This is controlled by an external circuit (not shown).

In dynamic operation, e.g. in the presence of a speech signal at voltage generator 4, the voltage of line V_L oscillates around a value V_{L0} determined by the above relation.

30 The current control of LED 1 is made through the second loop, that is the current source 7, operational amplifier 6, resistors R3, R4, diode D3 and transistors T3, T4, T5. Resistor R3 has a low value and is used for measuring the current I_{LED} in LED 1 (flowing in the components 1, R3, T2 and R5).

This current I_{LED} is compared with a reference current generated by the generator 7 which flows in resistor R_4 . This second feed-back loop controls a limited portion of the line current I_L to flow in the LED 1. So, as shown in figure 4, as long as the
 5 line current I_L is lower than a threshold value I_{s2} , the current in LED 1 varies like the current I_L . As soon as the line current I_L is sufficient, the current in LED 1 is limited to this threshold value I_{s2} .

The threshold value I_{s2} is determined by the values of
 10 resistors R_3 and R_4 and of the current I_{ref} provided by the reference current source 7:

$$I_{s2} = I_{ref} \cdot R_4 / R_3$$

The remaining portion of the line current, that is the difference between the line current I_L and the threshold current
 15 I_{s2} , flows in transistor T_3 . However, if I_L becomes lower than I_{s2} , the loop saturates. Therefore, transistor T_3 cuts off and the input voltages of the operational amplifier 6 are no longer equal. In such an instance, the current in LED 1 is equal to I_L .

The third loop controls the circuit of Fig. 1 to avoid
 20 a distortion of the transmitted signal for high amplitude swings of the speech signal. It derives current from LED 1 when the negative swings of the speech signals have a value such that the line voltage V_L is lower than a threshold voltage V_{s1} . Accordingly, the transistor T_2 does not saturate and does not cause a
 25 distortion of the transmitted signal.

The two inputs of the transconductance amplifier 9 are respectively connected to the collector and, through diode D_2 , to the emitter of transistor T_2 . A minimum voltage drop, equivalent to V_{be} , is accordingly permanently maintained between the
 30 collector and the emitter of transistor T_2 if the line voltage gets lower than the threshold value V_{s1} . Indeed, in this case, the feed-back loop of amplifier 9 causes transistor T_6 to be on. Thus, transistor T_3 shorts the serial connection of LED 1 and resistor R_3 . This third loop also cancels, through transistor
 35 T_4 , the operation of the second loop that controls the current of LED 1.

When the voltage V_L is higher than the threshold voltage V_{s1} , the third loop saturates. Transistor T6 cuts off. Thus, this third loop is not active during the positive swings or the low value negative swings of the line voltage V_L .

5 The effect of the third loop is particularly useful when the reference voltage V_0 is low. Under such conditions, the risk of saturating transistor T2 during the negative swings increases if LED 1 is not shunted since V_0 is also equal to the LED drop plus the collector-emitter drop of the transistor T2
10 plus the drop in the resistor R3 as forced by the first loop.

Fig. 4 shows the current I_{led} in LED 1 as a function of the line current I_L in the absence of speech signals.

As long as the line current I_L does not reach a value I_{s1} corresponding to the threshold voltage V_{s1} , the LED 1 is
15 shunted (phase 1) and no current flows therein. This results from the action of the third loop, the second loop being saturated.

When the line current has a value between the threshold current I_{s1} and the threshold current I_{s2} , $I_{led}=I_L$ (phase
20 2). This is a result of the action of only the first loop, the two other loops not being operative.

When the line current I_L is higher than the threshold value I_{s2} , I_{led} is limited to I_{s2} (phase 3). This is a result of the action of the second loop, the third loop being saturated.

25 Figs. 5-8 are time diagrams illustrating the operation phases as a function of the speech signal swings. These figures represent the line voltage V_L that corresponds to the anode potential of LED 1 and the potential V_k on the cathode of LED 1. In these figures, the line current I_L is assumed to be higher
30 than the threshold value I_{s2} in the absence of speech signal. In other words, the circuit is in the low slope portion of the voltage-current characteristic of Fig. 3.

Fig. 5 shows small swings of the line voltage V_L , that is a speech signal having a low amplitude around V_{L0} . In this
35 case, the LED 1 is permanently conductive and $V_k=V_L-V_D$, V_D being

the nominal voltage drop of the LED 1. Fig. 5 corresponds to the phase 3 of figure 4 for which the second loop is operative while the third loop is not operative.

Fig. 6 illustrates higher swings of the speech signal around the value V_{L0} such that the negative swings of V_L reach the threshold value V_{s1} . In this case, the third loop becomes operative and shunts the LED 1 (phase 1). The collector-emitter voltage of transistor T2 is maintained at V_{be} by the third loop. Accordingly, the potential V_k of the cathode of LED 1 is also maintained at a voltage V_{S2} which is equal to V_{be} plus the voltage drop in resistor R5 ($V_{S2}=V_{be}+I_{LR5}$). The drop across the LED, V_L-V_k , is now less than its normal value V_D . This is due to partial shunting of the LED. This situation continues for still higher signal excursions until the LED is fully shunted, i.e. the LED drop is equal to $V_{be(3)}+V_{CEsat(6)}$, where $V_{be(3)}$ is the base-emitter voltage of the transistor T3 and $V_{CEsat(6)}$ is the saturation collector-emitter voltage of the transistor T6.

If the negative swings of the speech signal cause the line voltage V_L to be at a still lower value, the voltage V_k of the cathode of LED 1 will not be maintained at V_{S2} . This is because the third loop now saturates with the LED fully shunted and therefore, the collector-emitter voltage of transistor T2 drops below V_{be} . The cathode voltage of LED 1 now decreases to $V_L-V_{be(3)}-V_{CEsat(6)}$. As long as the transistor T2 does not saturate, V_k follows the variation of the line voltage V_L , exemplified by the clip in V_k at the bottom as shown in Fig. 7. Thus, the circuit remains in phase 1 when the first and third loops are active as shown in Fig. 7, providing a transmission without distortion of the speech signal.

Fig. 8 shows speech signal oscillations that are such that the line voltage V_L gets even lower further and causes the saturation of transistor T2. The speech signal is longer transmitted without distortion even in the absence of current flowing through LED 1 which is fully shunted at these very low volt-

ages. The value $I_{LR5} + V_{CEsat}(2)$ (where $V_{CEsat}(2)$ is the saturation collector-emitter voltage of the transistor T2) for voltage VL at its negative excursion thus constitutes the limit of the operation of the amplifier according to the invention to
 5 transmit an undistorted signal.

As an example, in one embodiment the LED 1 may have a nominal voltage VD equal to 2 V. We assume that there is on the line a DC line voltage VL0 varying between 3.5 and 5.5 V for IL = 20 mA and 100 mA respectively, and a speech signal whose
 10 swings are not higher than 2 V peak. Then, it is possible to select for the resistors and capacitors the following values:

	R1 : 17 k Ω ;	C1 : 4.7 μ F;
	R2 : 39 k Ω ;	C2 : 5 pF;
	R3 : 6 Ω ;	C3 : 20 pF;
15	R4 : 5 k Ω ;	C4 : 20 pF;
	R5 : 20 Ω ;	C5 : 100 μ F;
	R6 : 9 k Ω ;	C6 : 10 nF;
	R7 : 600 Ω .	

For IL = 20 mA, the collector-emitter voltage of
 20 transistor T2 is about 1.1 V. It is equal to 1.5 V when IL = 100 mA. In the absence of the third loop, the voice signal would be distorted as soon as the speech signal swings attain a peak value of about 0.9 V ($1.1 \text{ V} - V_{CEsat}(2)$ at IL = 20 mA and 1.3 V at IL = 100 mA). With the invention, this signal is not
 25 distorted. This is due to the fact that LED drop of 2 V is shunted with a lower voltage equal to 0.9 V ($V_{be}(3) + V_{CEsat}(6)$). Therefore, there is at least $2.0 - 0.9 = 1.1 \text{ V}$ more room for the transistor T2 to saturate.

Fig. 9 shows an example of a detailed implementation
 30 of the circuit of Fig. 2. This circuit comprises the terminals A, B, M+ and M-. This circuit also comprises a terminal Vcc which gives a separate and stable supply for the amplifier A1 3. The Vcc supply is obtained from the line by means of a resistor R12 and a capacitor C7 serial connected between

terminals A and B. The Vcc supply is also used to generate the bias currents of some transistors of the circuit and especially those constituting the amplifier A1 3. The details of the circuitry for obtaining those currents are not shown. Only two
 5 terminals, respectively Bias P and Bias N are represented in Fig. 9.

The operational amplifier A1 3 comprises eleven bipolar transistors T7-T17. The non-inverting input of amplifier 3 corresponds to the base of an NPN transistor T7. Its inverting
 10 input corresponds to the base of an NPN transistor T8. Its output is taken on the emitter of a PNP transistor T9. The collector of transistor T7 is connected to terminal Vcc while its emitter is connected to the collector of an NPN transistor T10 whose emitter is grounded (terminal B). The emitter of
 15 transistor T7 is also connected to the base of a PNP transistor T11. The emitter of transistor T11 is connected, with the emitter of a PNP transistor T12, to the collector of a PNP transistor T13 whose emitter is connected to terminal Vcc. The base of transistor T12 is connected to the emitter of transistor
 20 T8 whose collector is connected to terminal Vcc and whose base constitutes the inverting input of amplifier 3. The emitter of transistor T8 is also connected to the collector of an NPN transistor T14 whose emitter is grounded. The collectors of transistors T11, T12 are respectively connected to the collect-
 25 ors of NPN transistors T15, T16. The bases of transistors T15, T16 are connected to the collector of transistor T15 and their emitters are grounded. The collector of transistor T16 is connected to the base of transistor T9 whose collector is grounded. The emitter of transistor T9, which constitutes the
 30 output of amplifier 3, is connected to the collector of a PNP transistor T17 whose emitter is connected to terminal Vcc. The bases of transistors T13 and T17 are connected to terminal Bias P.

The operational amplifier A2 6 comprises five bipolar transistors T18-T22. The non-inverting input of amplifier 6 corresponds to the base of a PNP transistor T18. Its inverting input corresponds to the base of a PNP transistor T19 while its
 5 output corresponds to the collector of transistor T19. The emitter of transistor T18 is connected, with the emitter of transistor T19, to the collector of a PNP transistor T20 whose emitter is connected to terminal A. The collectors of transistors T18, T19 are respectively connected to the
 10 collectors of NPN transistors T21, T22. The bases of transistors T21, T22 are connected to the collector of transistor T21 and their emitters are grounded.

The transconductance amplifier gm 9 comprises six bipolar transistors T23-T28. The non-inverting input of amplifier
 15 9 corresponds to the base of a PNP transistor T23. Its inverting input corresponds to the base of a PNP transistor T24 while its output is taken on the collector of a PNP transistor T25 through a resistor R8. The emitter of transistor T23 is connected, with the emitter of transistor T24, to the collector of a PNP transistor T26 whose emitter is connected to terminal A. The collec-
 20 tors of transistors T23, T24 are respectively connected to the collectors of NPN transistors T27, T28. The bases of transistors T27, T28 are connected to their own collector while their emitters are grounded. The emitter of transistor T25 is grounded and
 25 its base is connected to the collector of transistor T24. A resistor R9 is connected between a resistor R8 and terminal A.

The reference current generator 7 and the polarization generators 5 and 8 respectively correspond to PNP transistors T29, T30, T31. The emitters of transistors T29 and T31 are
 30 connected to terminal A while the emitter of transistor T30 is connected to terminal Vcc. The output of each generator 5, 7, 8 respectively corresponds to the collector of a respective transistor T30, T29, T31. The positive temperature coefficient current source 10 comprises an NPN transistor T32 whose emitter is

grounded and whose collector is connected to the positive input M+ of the microphone amplified signal. The diodes D1 and D2 correspond to respective NPN transistors T33, T34 whose base and collector are interconnected. The circuit also comprises three
5 transistors T35, T36, T37 for biasing the various transistors of the amplifiers 6 and 9. The emitter of a PNP transistor T35 is connected to terminal A while its collector is connected to the base of a PNP transistor T36 and to the collector of an NPN transistor T37. The emitter of transistor T37 is grounded. The
10 emitter of transistor T36 is connected with the base of transistor T35 while the base of transistor T37 is connected to terminal Bias N. The bases of transistors T20, T26, T29, T30, T31 are connected together to the emitter of transistor T36 while the bases of transistors T10, T14 and T32 are connected to
15 the base of transistor T37 (terminal Bias N). A resistor R10 is arranged between the inputs M+ and M- of the speech signal and a resistor R11 is arranged between base and emitter of transistor T3.

The other elements appearing on Fig. 9 are designated
20 by the same reference as in Fig. 2.

Of course, many variants and modifications of the invention will appear to those skilled in the art. In particular, each of the disclosed components (operational amplifiers, transconductance amplifier, current sources, diodes, ...) can be
25 replaced by one or a plurality of elements having the same or similar function. For example, the current sources made by means of transistors could be made by means of resistors.

Having thus described at least one illustrative embodiment of the invention, various alterations, modifications,
30 and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only, and not intended to be limiting. The invention is limited
35 only as defined in the following claims and the equivalents thereto.

What is claimed is:

CLAIMS

1. A transmit amplifier for a telephone set without self supply, comprising a LED (1) having an anode connected to a first positive terminal (A) of the telephone line and means for determining the ratio between the line current (I_L) and the line voltage (V_L), characterized in that said LED (1) is in series with the transmit amplifier which comprises deriving means for deriving the current flowing in LED (1) when the voltage (V_L) across the terminals (A, B) of the line becomes lower than a predetermined value (V_{s1}).
2. The transmit amplifier of claim 1, wherein it further comprises supply means for supplying LED (1) with a constant current, said deriving means being also able to disconnect said supply means.
3. The transmit amplifier of claim 2, wherein said supply means comprise a first operational amplifier (6) measuring the current (I_{led}) in the LED (1) and whose feed-back loop limits this current (I_{led}) to a value (I_{s2}) determined by a reference current generator (7).
4. The transmit amplifier of claim 3, wherein the cathode of LED (1) is connected to the non-inverting input of said first amplifier (6).
5. The transmit amplifier of claim 3 or 4, wherein said reference current generator (7) comprises a bipolar PNP transistor (T29) having an emitter connected to the first terminal (A) of the line and a collector connected to the inverting input of said first amplifier (6).
6. The transmit amplifier of claim 1 or 2, wherein said deriving means comprise a transconductance amplifier (9) whose feed-back loop controls a switch that derives the current of the LED (1).
7. The transmit amplifier of claim 6, wherein said switch comprises an NPN transistor (T3) whose collector is connected to the first terminal (A) of the line and whose emitter is connected, through a low value resistor (R3), to the cathode of the LED (1).



8. The transmit amplifier of any of claims 1 to 7, wherein said means for determining the ratio between the line current (IL) and the line voltage (VL) comprise a second operational amplifier (3) whose inverting input receives the speech
5 signal to be transmitted, added to a DC component of the line voltage (VL0) provided by a telephone exchange.

9. The transmit amplifier of claims 6 and 8, wherein the feed-back loop of said second amplifier (3) comprises two Darlington-connected NPN transistors (T1, T2) and two diodes
10 (D2, D1), the collector of the second transistor (T2) being connected to the inverting input of the transconductance amplifier (9) and the non-inverting input of the transconductance amplifier (9) being connected to the anode of the second diode (D2).