

SPECIFICATION

Telephone transmission circuit

- 5 The present invention concerns a telephone transmission circuit, and more particularly an improvement in a telephone transmission circuit of the type which incorporates an amplifier.
- 10 The use of amplifiers in telephone sets has recently received the attention of industry because of improved performance and reduced prices of such sets resulting from integrated circuit development.
- 15 This type of transmission circuit proposed heretofore in the art comprises at its two line terminals, a series circuit including two resistors, a power circuit for a receiver amplifier and a balancing network (See "Electronic Push-button Telephone Set—ERICOFON 700" by Arne Boeryd et al, ERICSSON REVIEW, No. 3, 1976, pp. 118-132). Between the connecting point of two resistances and one of the line terminals are connected a
- 25 power circuit for the transmitter amplifier and its output circuit. The input for the receiver amplifier is directly connected to one of the line terminals, while the output of the receiver amplifier is connected to the other line terminal via the balancing network. Thus, the power circuit for the receiver amplifier is supplied electric current from the line terminal via the two resistances resulting in power loss. As for the transmitter amplifier, a power source
- 30 current and an output signal current are supplied via one resistance, thereby unavoidably lowering the maximum distortionless output. With the conventional type transmission circuit, the impedance of the balancing network must be small, resulting in an increase of the size of the capacitor used. As the impedance of the transmission circuit depends on the impedance of the balancing network, a change of the impedance of the balancing
- 40 network adversely affects the desired matching of the line impedance and the transmission circuit impedance.
- Accordingly, a primary object of the present invention is to provide a telephone transmission circuit with less power loss and a larger maximum distortionless output.
- 50 A second object of the present invention is to provide a telephone transmission circuit with a compact balancing network.
- 55 A third object of the present invention is to provide a telephone transmission circuit which provides a better matching with the lines even when the balancing network conditions vary.
- The telephone transmission circuit according to the present invention includes a transmitter amplifier which amplifies voice frequency signals from a microphone, a receiver amplifier which amplifies voice frequency signals transmitted from the line, a serially
- 60 connected circuit of a first resistance, a second

- resistance and a balancing circuit to be connected between the first and second line terminals. A power circuit and an output circuit for the transmitter amplifier are connected
- 70 between a connecting point of the first resistance and the second resistance and the second line terminal. In parallel to the serially connected circuit, the receiver amplifier is connected via a constant current circuit. The input signals for the receiver amplifier are supplied via the connecting point of the second resistance and the balancing circuit. Here the first and the second line terminals are connected to the line via a circuit which
- 75 would at least maintain the polarity of the DC current constant. The phrase of "via the constant current circuit" includes the composition where the power circuit of the receiver amplifier becomes substantially the constant current
- 80 circuit.

According to the specific feature of the present invention, there is further included means to automatically adjust the conditions for balancing and the conditions for line equalization depending on whether the lines to be connected are far or near from the exchange.

The invention is further explained by reference to the accompanying drawings wherein:-

- 95 *Figure 1* is a diagram showing the conventional type telephone transmission circuit;
- Figure 2a* is a diagram showing a first embodiment of the present invention;
- 100 *Figure 2b* is a circuit diagram for a receiver amplifier which includes a constant current circuit used in the first embodiment of the present invention;
- Figure 3* shows a balancing network circuit used in the embodiment of the present invention;
- 105 *Figure 4* is a diagram showing a second embodiment of the present invention;
- Figure 5* shows a circuit diagram for a third
- 110 embodiment of the present invention;
- Figure 6* shows a line equalizing circuit used in the third embodiment of the present invention.

- Fig. 1* shows a conventional type transmission circuit wherein a power terminal for a receiver amplifier RA is connected to a line terminal L_1 via a series circuit of two resistances R_1 and R_2 , and a power source and an output terminal for a transmitter amplifier TA
- 120 are connected to the connection point of resistances R_1 and R_2 . The input to the receiver amplifier is supplied directly from the line terminal L_1 , while the other end of the output from the receiver amplifier RA is connected to
- 125 another line terminal L_2 via a balancing network Z_b .

This type of conventional transmission circuit suppresses sidetones by using the balancing network. The power circuit for the transmission amplifier TA and the receiver amplifier

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RA are supplied direct current from the line terminals L_1 and L_2 . As is clear from Fig. 1, however, the power source current for the receiver amplifier RA passes the resistance R_1 and R_2 , thereby causing losses in power. As for the transmission amplifier TA, the power source current and the output signals pass the resistance R_1 , thereby decreasing the distortionless output.

In further describing the problems encountered by the conventional type circuit, the transmitting attenuation b_T in the conventional type circuit shown in Fig. 1 is expressed by the following formula:

$$b_T = 20 \log (Z_L + R_1 + \frac{1+n}{n} \cdot Z_T) - 10 \log Z_T \cdot Z_L - 6 \text{ (dB)} \quad (1)$$

wherein

Z_L is the characteristic impedance for the line,

Z_T is the output impedance of the transmission amplifier TA,

n is expressed by the formula:

$$n = \frac{R_2}{R_1} = \frac{Z_b}{Z_L} \quad (2)$$

and is the balancing parameter showing the ratio of the balancing network impedance to the line impedance when the side tone balancing conditions hold.

In the above formula (1), since the characteristic impedance of the line Z_L is constant, and the output impedance Z_T of the transmitter amplifier TA is subjected to restrictions by the characteristic impedance of the circuit, it is necessary to reduce the resistance R_1 in order to decrease the attenuation b_T . As mentioned above, the power source current passes the resistance R_1 , it is all the more desirable that the value of R_1 be smaller.

On the other hand, the receiving attenuation b_R is expressed by the following formula:

$$b_R = 20 \log [Z_L (1 + n + \frac{Z_R}{R_1}) + R_1] - 10 \log Z_R \cdot Z_L - 6 \text{ (dB)} \quad (3)$$

wherein Z_R is the impedance for the receiver amplifier.

From the formula (2), it is understood that the receiving attenuation b_R increases if the value of the resistance R_1 is radically decreased as compared to the impedance Z_R of the receiver amplifier. Since the power source current for the receiver amplifier RA passes through the resistances R_1 and R_2 and the balancing network Z_b , these values are also

preferred to be smaller.

Considering these conditions, the values of the resistances R_1 and R_2 and the impedance of the balancing network Z_b must be selected to be small, and yet the value of R_1 can not be made too small. Accordingly, the value n of the balancing parameters necessarily becomes small. Thus, the defects of the circuit shown in Fig. 1 are enumerated in the following way.

(1) The impedance of the balancing network,

$$Z_b = nZ_L$$

becomes approximately equal or more than Z_L , thereby increasing the size of the capacitor in the balancing network. This is a disadvantage with respect to the packaging.

(2) The impedance Z_0 of the transmission circuit viewed from the line side is related to Z_b , and therefore if Z_b is varied for balancing the side-tones, then Z_0 is also varied, thereby causing mismatching with the line.

(3) As the transmission attenuation b_T is large, the gain for the transmitter amplifier TA becomes larger if the desired output is to be achieved, which in turn decreases the distortionless maximum output.

Fig. 2 shows a circuit diagram of one embodiment of the present invention. To the line terminals L_1 and L_2 are connected a first resistance R_1 , a second resistance R_2 and a balancing network Z_b in series. A transmission amplifier TA and its power source circuit is connected between the connecting point of resistances R_1 and R_2 and the line terminal L_2 . Further between the line terminal L_1 and the line terminal L_2 is connected a power source circuit for a receiver amplifier RA. The input of the receiver amplifier RA is connected to the connecting point of the resistance R_2 and the balancing network Z_b .

In the circuit having a composition such as the above, as the power source current for the amplifier does not flow through the resistance R_2 and the network Z_b , there is less of the power loss. Since it is possible to select larger values for the resistance R_2 and the network impedance Z_b , the balancing parameter n shown in Equation (2) may be increased.

Accordingly the impedance Z_b can be made larger than the characteristic impedance Z_L of the line, decreasing the size of the capacitor which constitutes the network Z_b . In this embodiment, the value of n may be selected to be 10.

In this embodiment, there is further included a constant current circuit in the power source circuit for the receiver amplifier RA. Specifically, as shown in Fig. 2b, the receiver amplifier circuit includes an operational amplifier 10 and a constant current circuit. The constant current circuit includes a resistance R_9 , a series circuit of diodes D_5 and D_6 , a transistor Q_1 , and a resistance R_{10} connected to the emitter of the transistor. The base of

the transistor Q1 is connected to the connecting point of the anode for the diode D5 and the resistance R9, and the emitter is connected to the line terminal L₂ via the resistance R10. By connecting the operational amplifier 10 between the line terminal L₁ and the collector of the transistor Q1, it is possible to supply the collector current of the transistor Q1. When the operational amplifier is connected to the lines L₁ and L₂ via such a constant current circuit, the impedance Z₀ seen from the line side of this circuit is not effected. Moreover, as n is large, the relationship of

$$R_2 + Z_a \gg Z_T$$

holds compared to the output impedance Z_T of the transmitter amplifier TA. The impedance Z₀ may be deemed to have the relationship of

$$Z_0 \approx R_1 + Z_T$$

Accordingly, variation of the balancing network Z_a for the purpose of balancing the side tones hardly influences Z₀ and does not impair matching with the line.

In this circuit the value of the resistance R₁ becomes smaller, the output of the transmission amplifier TA is effectively transmitted to the line with small loss. It is also possible to feed sufficient power source current to the transmitter amplifier TA. Thus, it is also possible to increase the distortionless maximum output of the transmission amplifier TA.

Fig. 3 is a circuit diagram of a preferred balancing network Z_a for use in the present invention. A resistance R3 is connected in parallel to a circuit connecting a resistance R4 and a capacitor C₁ in series. The series circuit of Zener diode ZD₁ and resistance R₅ is connected in parallel to the capacitor C₁.

The balancing network Z_a is so constructed that when the line is long, the terminal voltage is low, and the Zener diode ZD₁ is in the off condition. When the line length is short, the power arriving at the telephone circuit will be sufficiently large to turn on the Zener diode ZD₁, thereby placing resistance R5 in parallel with capacitor C₁. The impedance suppresses the sidetone at a short distance. In short, sidetone balancing is achieved with little loss in each of the two applicable regions depending on the line lengths. Even when the impedance of the balancing network Z_a is thus varied, the impedance Z₀ of the transmission circuit hardly varies, as discussed earlier. In one specific example, the above mentioned resistances and the capacitor may be selected to have the following values:

R₃ is 8.2 KΩ, R₄ is 3.6 KΩ,
R₅ is 12 KΩ and C₁ is 0.01 μF,

and the Zener diode ZD₁ may be selected to

have a breakdown voltage of 7 V.

Fig. 4 is a circuit diagram of a second embodiment of the present invention. This embodiment is characterized in that the receiver amplifier RA has differential input terminals, and one of the inputs is connected to the line terminal L₁. Other components of the embodiment are the same as that shown in Fig. 2. Accordingly, the description of the detailed operation and the operational effect is omitted.

Fig. 5 shows a third embodiment of the present invention. The transmission amplifier TA includes a main amplifier A₁, a pre-amplifier A₂, a RC smoothing circuit N₁, and a line equalization circuit TAL. The RC smoothing circuit N₁ comprises a series circuit of a resistance R₆ and a capacitor C₂ connected between the contact point of the resistances R₁ and R₂ and the line terminal L₂. The output of the RC smoothing circuit or the power source circuit N₁ is supplied to the pre-amplifier A₂ and the power source terminals W and X of the line equalization circuit TAL. The output terminals Y and Z which are controlled by the line equalization circuit TAL, are connected in parallel to a microphone M, and the resistance between the terminals Y and Z of the line equalization circuit TAL varies depending on the variation of the output from the RC smoothing circuit, thereby controlling the input to the pre-amplifier A₂. In other words, the output from RC smoothing circuit N₁ becomes greater at a short distance, and the operational resistance between the output terminals Y and Z of the equalizing circuit TAL becomes smaller. This will add the parallel loss to the microphone M. At a greater distance, the output from RC smoothing circuit N₁ becomes smaller, the operational resistance between Y and Z of the line equalization circuit TAL greater, thereby decreasing the parallel loss at the microphone M.

The receiver amplifier RA includes a line equalization circuit RAL. The input to the receiver amplifier is connected to the input resistance R₈ via the resistance R₇ from the connecting point of the resistance R₂ and the side tone balancing circuit Z_a. The line equalization circuit RAL is connected in parallel to the input resistance R₈. A DC voltage of the smoothing circuit N₁ is supplied to the power source terminals W and X of the line equalization circuit RAL. The output terminals Y and Z, which are controlled by the equalization circuit RAL, are connected to the input terminal of the receiver amplifier RA and adjust the receiver input depending on the voltage of the smoothing circuit, thereby performing the line equalization. In other words, the equalization circuit RAL acts as a parallel variable resistance for the resistance R₈.

Both equalization circuits TAL and RAL are embodied with identical circuit structures. As shown in Fig. 6, the equalization circuits are

constructed by connecting in parallel the series circuit of diodes D_1 and D_3 , and the series connected circuit of diodes D_2 and D_4 in the sequential order. There are connected a resistance R_W to the connecting point of the diodes D_1 and D_2 and a resistance R_X to the connecting point of the diodes D_3 and D_4 , and the respective other ends of these resistances R_W and R_X are the power source terminals W and X . The connecting point of the diodes D_1 and D_3 and the connecting point of the diodes D_2 and D_4 become the controlled output terminals Y and Z . The DC voltage supplied between terminals W and X controls the DC current of diodes $D_1 \sim D_4$.

The above line equalization circuit is a variable impedance alternating current shunt inserted in parallel to the input impedance of the microphone or the receiver amplifier. The impedance of the shunt is controlled by the voltage supplied. Since an increased DC current flowing in the diodes generally results in a decrease of the operational resistance of the diodes, the operational resistance between the controlled output terminals Y and Z becomes decreased by the increased DC voltage supplied to the power source terminals W and X .

Thus, it is not necessary for the line equalization circuits TAL and RAL to provide new power source circuits since the voltage of the smoothing circuit N_1 for the preamplifier included in the transmitter amplifier is utilized. It also acts as an automatic variable attenuator for the input to the receiver amplifier and the transmitter amplifier TA . Accordingly, since the automatic variable attenuator is connected to the input terminals of the amplifiers with a lower AC signal level both for transmission and receiving, non-linear distortions which often appear with the automatic gain variable circuit become negligibly small. If the resistance R_7 is selected to be comparatively large, then both the equalization circuits RAL and TAL become irrelevant to the impedance Z_0 of the transmission circuit.

In the above mentioned embodiment, the resistance R_1 was selected to be 30Ω , the resistance R_2 , 300Ω , the resistance R_6 , 820Ω , the resistance R_7 , $7.5\text{ K}\Omega$, and the resistance R_8 , $4\text{ K}\Omega$.

As discussed heretofore, the telephone set utilizing the transmission circuit in accordance with the present invention has such superior advantages as

(1) the power of the source is effectively utilized since the power source current for the receiver amplifier does not pass the resistances or the impedance,

(2) the distortionless maximum output voltage is increased since the output loss of the transmission amplifier may be minimized,

(3) the size of the capacitor for the balancing network becomes compact, which proves advantageous for packaging, and

(4) the impedance for the transmission

network does not change because of the line equalization, performing good matching to the telephone line.

The telephone set according to the present invention is further advantageous since it is provided with a circuit which automatically detects the DC voltage of the lines, and it automatically changes the side tone balancing conditions so that good balancing is maintained constantly.

It is also possible to provide a circuit which automatically changes the operational conditions of the receiver amplifier or the transmission amplifier depending on the size of the DC voltage of the lines, thereby automatically adjusting the transmission level of the respective amplifiers.

CLAIMS

1. A telephone transmission circuit for connection to a line having first and second line terminals, said telephone transmission circuit comprising; a microphone for providing voice frequency signals, a transmitter amplifier means for amplifying voice frequency signals from said microphone, a receiver amplifier means for amplifying voice frequency signals received on said line, and a serially connected circuit means connected between first and second line terminals, said circuit means comprising a first resistance, a second resistance, and a balancing network for preventing the output from said transmitter amplifier from entering said receiver amplifier, said transmitter amplifier and said receiver amplifier being supplied with DC current from said first and second line terminals, said transmitter amplifier being connected between the connecting point of said first and second resistances and said second line terminal, said receiver amplifier being connected in parallel with said serially connected circuit means via a constant current circuit, and the input signals of said receiver amplifier being supplied via the connecting point of said second resistance and said balancing network.

2. A telephone transmission circuit as claimed in claim 1, wherein said balancing network includes a diode switch circuit turning on or off responsive to the voltage supplied between the said first and the second line terminals.

3. A telephone transmission circuit as claimed in claims 1 or 2 further comprising a smoothing circuit means for smoothing a voltage supplied from said line to said transmitter and receiver amplifiers, said smoothing circuit comprising, a third resistor having one end connected to the connection point of said first and second resistor, and a first capacitor having one end connected to the other end of said third resistor and the other end connected to said second line terminal.

4. The telephone transmission circuit as claimed in claim 3, further comprising a first



constructed by connecting in parallel the series circuit of diodes D_1 and D_3 , and the series connected circuit of diodes D_2 and D_4 in the sequential order. There are connected a resistance R_W to the connecting point of the diodes D_1 and D_2 and a resistance R_X to the connecting point of the diodes D_3 and D_4 , and the respective other ends of these resistances R_W and R_X are the power source terminals W and X . The connecting point of the diodes D_1 and D_3 and the connecting point of the diodes D_2 and D_4 become the controlled output terminals Y and Z . The DC voltage supplied between terminals W and X controls the DC current of diodes $D_1 \sim D_4$.

The above line equalization circuit is a variable impedance alternating current shunt inserted in parallel to the input impedance of the microphone or the receiver amplifier. The impedance of the shunt is controlled by the voltage supplied. Since an increased DC current flowing in the diodes generally results in a decrease of the operational resistance of the diodes, the operational resistance between the controlled output terminals Y and Z becomes decreased by the increased DC voltage supplied to the power source terminals W and X .

Thus, it is not necessary for the line equalization circuits TAL and RAL to provide new power source circuits since the voltage of the smoothing circuit N_1 for the preamplifier included in the transmitter amplifier is utilized. It also acts as an automatic variable attenuator for the input to the receiver amplifier and the transmitter amplifier TA . Accordingly, since the automatic variable attenuator is connected to the input terminals of the amplifiers with a lower AC signal level both for transmission and receiving, non-linear distortions which often appear with the automatic gain variable circuit become negligibly small. If the resistance R_7 is selected to be comparatively large, then both the equalization circuits RAL and TAL become irrelevant to the impedance Z_0 of the transmission circuit.

In the above mentioned embodiment, the resistance R_1 was selected to be 30Ω , the resistance R_2 , 300Ω , the resistance R_6 , 820Ω , the resistance R_7 , $7.5\text{ K}\Omega$, and the resistance R_8 , $4\text{ K}\Omega$.

As discussed heretofore, the telephone set utilizing the transmission circuit in accordance with the present invention has such superior advantages as

(1) the power of the source is effectively utilized since the power source current for the receiver amplifier does not pass the resistances or the impedance,

(2) the distortionless maximum output voltage is increased since the output loss of the transmission amplifier may be minimized,

(3) the size of the capacitor for the balancing network becomes compact, which proves advantageous for packaging, and

(4) the impedance for the transmission

network does not change because of the line equalization, performing good matching to the telephone line.

The telephone set according to the present invention is further advantageous since it is provided with a circuit which automatically detects the DC voltage of the lines, and it automatically changes the side tone balancing conditions so that good balancing is maintained constantly.

It is also possible to provide a circuit which automatically changes the operational conditions of the receiver amplifier or the transmission amplifier depending on the size of the DC voltage of the lines, thereby automatically adjusting the transmission level of the respective amplifiers.

CLAIMS

1. A telephone transmission circuit for connection to a line having first and second line terminals, said telephone transmission circuit comprising; a microphone for providing voice frequency signals, a transmitter amplifier means for amplifying voice frequency signals from said microphone, a receiver amplifier means for amplifying voice frequency signals received on said line, and a serially connected circuit means connected between first and second line terminals, said circuit means comprising a first resistance, a second resistance, and a balancing network for preventing the output from said transmitter amplifier from entering said receiver amplifier, said transmitter amplifier and said receiver amplifier being supplied with DC current from said first and second line terminals, said transmitter amplifier being connected between the connecting point of said first and second resistances and said second line terminal, said receiver amplifier being connected in parallel with said serially connected circuit means via a constant current circuit, and the input signals of said receiver amplifier being supplied via the connecting point of said second resistance and said balancing network.

2. A telephone transmission circuit as claimed in claim 1, wherein said balancing network includes a diode switch circuit turning on or off responsive to the voltage supplied between the said first and the second line terminals.

3. A telephone transmission circuit as claimed in claims 1 or 2 further comprising a smoothing circuit means for smoothing a voltage supplied from said line to said transmitter and receiver amplifiers, said smoothing circuit comprising, a third resistor having one end connected to the connection point of said first and second resistor, and a first capacitor having one end connected to the other end of said third resistor and the other end connected to said second line terminal.

4. The telephone transmission circuit as claimed in claim 3, further comprising a first

line equalization circuit connected in parallel with said first capacitor of said smoothing circuit for varying input impedance of said transmitter amplifier depending on the charged voltage of said first capacitor.

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5. A telephone transmission circuit as claimed in claim 4, further comprising a second line equalization circuit connected in parallel to said first capacitor for varying the input impedance of said receiver amplifier depending on the charged voltage of said capacitor.

6. A telephone transmission circuit as claimed in claim 5 wherein each of said first and second line equalization circuits includes the series connection of first and second diodes connected sequentially, and the series connection of third and fourth diodes connected sequentially, each of said series connections being connected with one another.

7. A telephone transmission circuit substantially as hereinbefore described with reference to Fig. 2a, Fig. 4 or Fig. 5 of the accompanying drawings.

8. A telephone transmission circuit substantially as described herein with reference to Fig. 2a of the accompanying drawings incorporating a receiver amplifier and a balancing network substantially as described herein with reference to Fig. 2b and Fig. 3 respectively of the accompanying drawings.

9. A telephone transmission circuit substantially as described herein with reference to Fig. 5 of the accompanying drawings incorporating a line equalizing circuit substantially as described herein with reference to Fig. 6 of the accompanying drawings.

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