VERSATILE TELEPHONE TRANSMISSION CIRCUITS WITH DIALLER INTERFACE

GENERAL DESCRIPTION

The TEA1060 and TEA1061 are bipolar integrated circuits performing all speech, and line interface functions required in fully electronic telephone sets. The circuits internally perform electronic switching between dialling and speech.

Features

- Voltage regulator with adjustable static resistance
- Provides supply for external circuitry
- Symmetrical low-impedance inputs for dynamic and magnetic microphones (TEA1060)
- Symmetrical high-impedance inputs for piezoelectric microphone (TEA1061)
- Asymmetrical high-impedance input for electret microphone (TEA1061)
- DTMF signal input with confidence tone
- Mute input for pulse or DTMF dialling
- Power down input for pulse dial or register recall
- Receiving amplifier for magnetic, dynamic or piezoelectric earpieces
- Large amplification setting range on microphone and earpiece amplifiers
- Line loss compensation facility, line current dependent (microphone and earpiece amplifiers)
- Gain control adaptable to exchange supply
- DC line voltage adjustment facility

QUICK REFERENCE DATA

parameter	conditions	symbol	min.	typ.	max.	unit
Line voltage	I_{line} = 15 mA	V_{LN}	4.25	4.45	4.65	V
Line current operating range (pin 1)		I_{line}	10	–	140	mA
Internal supply current						
power down input LOW		I_{CC}	–	0.96	1.3	mA
power down input HIGH		I_{CC}	82	55	–	μA
Supply voltage for peripherals	I_{line} = 15 mA; MUTE input HIGH					
	I_P = 1.2 mA	V_{CC}	2.8	3.05	–	V
	I_P = 1.7 mA	V_{CC}	2.5	–	–	V
Voltage gain range						
microphone amplifier						
TEA1060		G_v	44	–	60	dB
TEA1061		G_v	30	–	46	dB
receiving amplifier		G_v	17	–	39	dB
Line loss compensation gain control range		ΔG_v	5.5	5.9	6.3	dB
Exchange supply voltage range		V_{exch}	24	–	60	V
Exchange feeding bridge resistance range		R_{exch}	400	–	1000	Ω
Operating ambient temperature range		T_{amb}	−25	–	+75	°C

PACKAGE OUTLINE

18-lead DIL; plastic (SOT102).

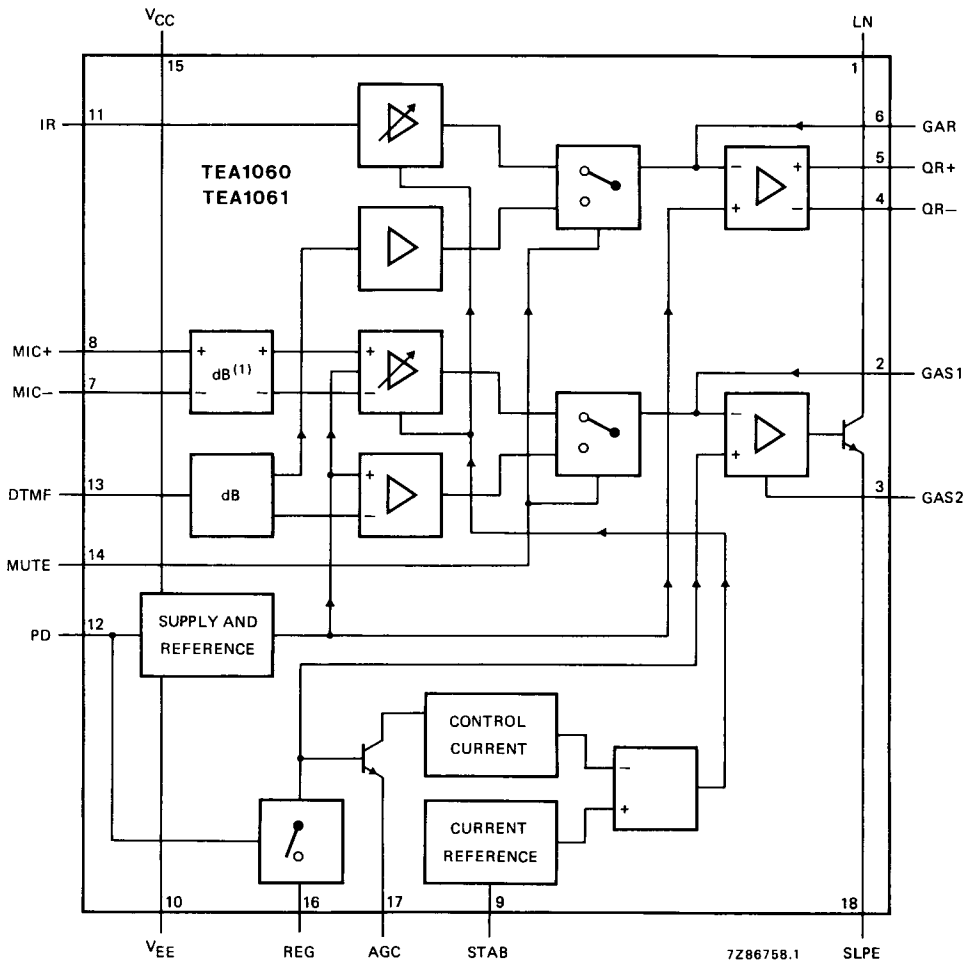


Fig.1 Block diagram.

The blocks marked "dB" are attenuators. The block marked (1) is only present in the TEA1061.

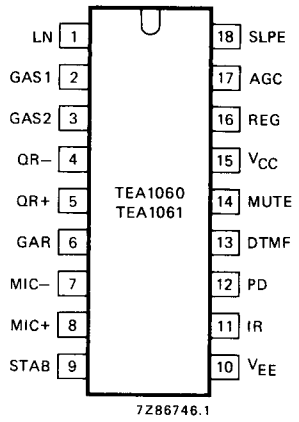


Fig.2 Pinning diagram.

PINNING

1	LN	positive line terminal
2	GAS1	gain adjustment; transmitting amplifier
3	GAS2	gain adjustment; transmitting amplifier
4	QR–	inverting output, receiving amplifier
5	QR+	non-inverting output, receiving amplifier
6	GAR	gain adjustment; receiving amplifier
7	MIC–	inverting microphone input
8	MIC+	non-inverting microphone input
9	STAB	current stabilizer
10	V_{EE}	negative line terminal
11	IR	receiving amplifier input
12	PD	power-down input
13	DTMF	dual-tone multi-frequency input
14	MUTE	mute input
15	V_{CC}	positive supply decoupling
16	REG	voltage regulator decoupling
17	AGC	automatic gain control input
18	SLPE	slope (DC resistance) adjustment

FUNCTIONAL DESCRIPTION

Supply: V_{CC}, LN, SLPE, REG and STAB

The circuit and its peripheral circuits are usually supplied from the telephone line. The circuit develops its own supply voltage at V_{CC} and regulates its voltage drop. The supply voltage V_{CC} may also be used to supply external peripheral circuits, e.g. dialling and control circuits.

The supply has to be decoupled by connecting a smoothing capacitor between V_{CC} and V_{EE}; the internal voltage regulator has to be decoupled by a capacitor from REG to V_{EE}. An internal current stabilizer is set by a resistor of 3.6 kΩ between STAB and V_{EE}.

The DC current flowing into the set is determined by the exchange supply voltage (V_{exch}), the feeding bridge resistance (R_{exch}), the DC resistance of the subscriber line (R_{line}) and the DC voltage on the subscriber set (see Fig.4).

If the line current (I_{line}) exceeds the current I_{CC} + 0.5 mA required by the circuit itself (I_{CC} ca. 1 mA), plus the current Ip required by the peripheral circuits connected to V_{CC}, then the voltage regulator diverts the excess current via LN.
The voltage regulator adjusts the average voltage on LN to:
$V_{LN} = V_{ref} + I_{SLPE} \times R9 = V_{ref} + (I_{line} - I_{CC} - 0.5 \times 10^{-3} A - I_P) \times R9$.

V_{ref} being an internally generated temperature compensated reference voltage of 4.2 V and R9 being an external resistor connected between SLPE and V_{EE}. The preferred value of R9 is 20 Ω. Changing R9 will have influence on microphone gain, DTMF gain, gain control characteristics, side tone and maximum output swing on LN.
Under normal conditions $I_{SLPE} \gg I_{CC}$ + 0.5 mA + Ip. The static behaviour of the circuit then equals a 4.2 V voltage regulator diode with an internal resistance R9. In the audio frequency range the dynamic impedance equals R1. The internal reference voltage can be adjusted by means of an external resistor R_{VA}. This resistor connected between pins 1 and 16 (LN and REG) will decrease the internal reference voltage. R_{VA} connected between pins 16 and 18 (REG and SLPE) will increase the internal reference voltage.

Supply: V_{CC}, LN, SLPE, REG and STAB (continued)

The current Ip available from V_{CC} for supplying peripheral circuits depends on external components and on the line current. Fig.5 shows this current for $V_{CC} > 2.2$ V and for $V_{CC} > 3$ V, of which 3 V is the minimum supply voltage for most CMOS circuits including a diode voltage drop for an enable diode. If MUTE is LOW the available current is further reduced when the receiving amplifier is driven.

Microphone inputs MIC+ and MIC− and gain adjustment connections GAS1 and GAS2

The TEA1060 and TEA1061 have symmetrical microphone inputs.
The TEA1060 is intended for low-sensitivity low-impedance dynamic or magnetic microphones. Its input impedance is 8.2 kΩ (2 x 4.1 kΩ) and its voltage amplification is typ. 52 dB.
The TEA1061 is intended for a piezoelectric microphone or an electret microphone with built-in FET source follower. Its input impedance is 40.8 kΩ (2 x 20.4 kΩ) and its voltage amplification is typ. 38 dB.
The arrangements with the microphone types mentioned are shown in Fig.6.

The gain of the microphone amplifier in both types can be adjusted over a range of + and −8 dB to suit the sensitivity of the transducer used. The gain is proportional to external resistor R7 connected between GAS1 and GAS2.

An external capacitor (C6) of 100 pF between GAS1 and SLPE is required to ensure stability. A larger value may be chosen to obtain a first-order low-pass filter. The cut-off frequency corresponds with the time constant R7 x C6.

Mute input MUTE

A HIGH level at MUTE enables the DTMF input and inhibits the microphone inputs and the receiving amplifier, a LOW level or an open circuit does the reverse. Switching the mute input will cause negligible clicks at the telephone outputs and on the line.

Dual-tone multi-frequency input DTMF

When the DTMF input is enabled, dialling tones may be sent onto the line. The voltage gain from DTMF to LN is typ. 25.5 dB and varies with R7 in the same way as the gain of the microphone amplifier. The signalling tones can be heard in the earpiece at a low level (confidence tone).

Receiving amplifier: IR, QR+, QR− and GAR

The receiving amplifier has one input IR and two complementary outputs, a non-inverting output QR+ and an inverting output QR−. These outputs may be used for single-ended or for differential drive, depending on the sensitivity and type of earpiece used (see Fig.7). The gain from IR to QR+ is typ. 25 dB. This will be sufficient for low-impedance magnetic or dynamic earpieces; these are suited for single-ended drive. By using both outputs (differential drive) the gain is increased by 6 dB and differential drive becomes possible.
This feature can be used in case the earpiece impedance exceeds 450 Ω (high-impedance dynamic, magnetic or piezoelectric earpieces).

The output voltage of the receiving amplifier is specified for continuous-wave drive. The maximum output voltage will be higher under speech conditions, where the ratio of peak and RMS value is higher.

The gain of the receiving amplifier can be adjusted over a range of + and −8 dB to suit the sensitivity of the transducer used. The gain is proportional to external resistor R4 connected from GAR to QR+.

Two external capacitors C4 = 100 pF and C7 = 10 x C4 = 1 nF are necessary to ensure stability.
A larger value of C4 may be chosen to obtain a first-order low-pass filter. The "cut-off" frequency corresponds with the time constant R4 x C4.

Automatic gain control input AGC

Automatic line loss compensation will be obtained by connecting a resistor R6 from AGC to V_{EE}. This automatic gain control varies the gain of the microphone amplifier and the receiving amplifier in accordance with the DC line current. The control range is 6 dB. This corresponds with a line length of 5 km for a 0.5 mm diameter copper twisted-pair cable with a DC resistance of 176 Ω/km and an average attenuation of 1.2 dB/km.

Resistor R6 should be chosen in accordance with the exchange supply voltage and its feeding bridge resistance (see Fig.8 and Table 1). Different values of R6 give the same ratio of line currents for begin and end of the control range. If automatic line loss compensation is not required AGC may be left open. The amplifiers then all give their maximum gain as specified.

Power-down input PD

During pulse dialling or register recall (timed loop break) the telephone line is interrupted, as a consequence it provides no supply for the transmission circuit and the peripherals connected to V_{CC}. These gaps have to be bridged by the charge in the smoothing capacitor C1. The requirements on this capacitor are relaxed by applying a HIGH level to the PD input during the time of the loop break, which reduces the supply current from typ. 1 mA to typ. 55 μA.

A HIGH level at PD further disconnects the capacitor at REG, with the effect that the voltage stabilizer will have no switch-on delay after line interruptions. This results in no contribution of the IC to the current waveform during pulse dialling or register recall.
When this facility is not required PD may be left open.

Side-tone suppression

Suppression of the transmitted signal in the earpiece is obtained by the antiside-tone network consisting of $R1//Z_{line}$, R2, R3, R8 and Z_{bal} (see Fig.11). Maximum compensation is obtained when the following conditions are fulfilled:

$$a)\ R9.R2 = R1[R3 + (R8//Z_{bal})]$$

$$b)\ |Z_{bal}/(Z_{bal} + R8)] = [Z_{line}/(Z_{line} + R1)\ ]$$

If fixed values are chosen for R1, R2, R3 and R9, then condition a) will always be fulfilled provided that $|R8//Z_{bal}| \ll R3$.

To obtain optimum side-tone-suppression, condition (b) has to be fulfilled resulting in:

$$Z_{bal} = (R8/R1)Z_{line} = k.Z_{line}$$

where k is a scale factor; $k = (R8/R1)$

Scale factor k (value of R8) must be chosen to meet the following criteria:

- compatibility with a standard capacitor from the E6 or E12 range for Z_{bal}
- $|Z_{bal}//R8| \ll R3$
- $|Z_{bal} + R8| \gg R9$

In practice Z_{line} varies strongly with line length and cable type; consequently an average value has to be chosen for Z_{bal}. The suppression further depends on the accuracy with which Z_{bal} equals the average line impedance.

The anti-side-tone network as used in the standard application (Fig.11) attenuates the signal from the line with 32 dB. The attenuation is nearly flat over the audio-frequency range.
Instead of the above described special bridge, the conventional Wheatstone bridge configuration can be used as an alternative anti-side tone circuit. Both bridges can be used with either a resistive set impedance or with a complex set impedance.

RATINGS

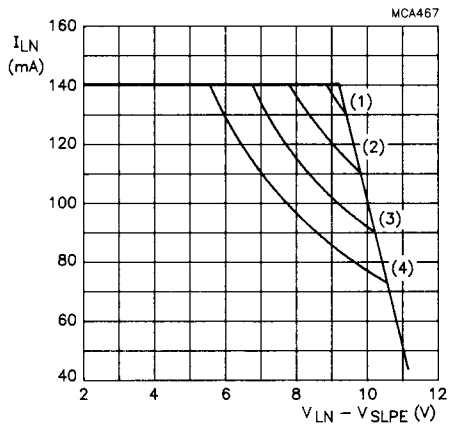
Limiting values in accordance with the Absolute Maximum System (IEC 134)

parameter	conditions	symbol	min.	max.	unit
Positive continuous line voltage		V_{LN}	–	12	V
Repetitive line voltage during switch-on or line interruption		V_{LN}	–	13.2	V
Repetitive peak line voltage for a 1 ms pulse per 5 s	R10 = 13 Ω; R9 = 20 Ω; (see Fig.11)	V_{LN}	–	28	V
Line current TEA1060 (1)	R9 = 20 Ω	I_{line}	–	140	mA
Line current TEA1061 (1)	R9 = 20 Ω	I_{line}	–	140	mA
Voltage on all other pins		V_i	–	V_{CC} + 0.7	V
		$-V_i$	–	0.7	V
Total power dissipation (2)		P_{tot}	–	769	mW
Storage temperature range		T_{stg}	−40	+ 125	°C
Operating ambient temperature range		T_{amb}	−25	+ 75	°C
Junction temperature		T_j	–	+ 125	°C

1. Mostly dependent on the maximum required T_{amb} and the voltage between LN and SLPE (see Fig.3).
2. Calculated for the maximum ambient temperature specified T_{amb} = 75 °C and a maximum junction temperature of 125 °C.

THERMAL RESISTANCE

From junction to ambient in free air
TEA1060 and TEA1061 $R_{th\ j\text{-}a}$ = 65 K/W



	T_{amb}	P_{tot}
(1)	45 °C	1231 mW
(2)	55 °C	1077 mW
(3)	65 °C	923 mW
(4)	75 °C	769 mW

Fig.3 TEA1060/1061 safe operating area.

CHARACTERISTICS

I_{line} = 10 to 140 mA; V_{EE} = 0 V; f = 800 Hz; T_{amb} = 25 °C, R9 = 20 Ω; unless otherwise specified

parameter	conditions	symbol	min.	typ.	max.	unit
Supply: LN and V_{CC} (pins 1 and 15)						
Voltage drop over circuit	I_{line} = 5 mA	V_{LN}	3.95	4.25	4.55	V
	I_{line} = 15 mA	V_{LN}	4.25	4.45	4.65	V
	I_{line} = 100 mA	V_{LN}	5.4	6.1	6.7	V
	I_{line} = 140 mA	V_{LN}	–	–	7.5	V
Variation with temperature	I_{line} = 15 mA	$\Delta V_{LN}/\Delta T$	−4	−2	0	mV/K
Voltage drop over circuit	I_{line} = 15 mA $R_{VA} = R_{1\text{-}16}$ = 68 kΩ	V_{LN}	3.5	3.8	4.05	V
	$R_{VA} = R_{16\text{-}18}$ = 39 kΩ	V_{LN}	4.7	5.0	5.3	V
Supply current	PD = LOW; V_{CC} = 2.8 V	I_{CC}	–	0.96	1.30	mA
	PD = HIGH; V_{CC} = 2.8 V	I_{CC}	–	55	82	μA
Supply voltage available for peripheral circuits	I_{line} = 15 mA; MUTE = HIGH					
	I_P = 0 mA	V_{CC}	3.5	3.75	–	V
	I_P = 1.2 mA	V_{CC}	2.8	3.05	–	V
Microphone inputs MIC+ and MIC− (pins 7 and 8)						
Input impedance						
TEA1060		$\lvert Z_i \rvert$	3.3	4.1	4.9	kΩ
TEA1061		$\lvert Z_i \rvert$	16.5	20.4	24.5	kΩ
Common-mode rejection ratio TEA1060		k_{CMR}	–	82	–	dB
Voltage gain	I_{line} = 15 mA; R7 = 68 kΩ					
TEA1060		G_v	51	52	53	dB
TEA1061		G_v	37	38	39	dB
Variation with frequency referred to 800 Hz	f = 300 and 3400 kHz	ΔG_{vf}	−0.5	±0.2	+0.5	dB
Variation with temperature referred to +25 °C	I_{line} = 50 mA; T_{amb} = −25 and +75 °C	ΔG_{vT}	–	±0.2	–	dB

CHARACTERISTICS (continued)

parameter	conditions	symbol	min.	typ.	max.	unit
Dual-tone multi-frequency input DTMF (pin 13)						
Input impedance		$\|Z_i\|$	16.8	20.7	24.6	kΩ
Voltage gain	I_{line} = 15 mA; R7 = 68 kΩ	G_v	24.5	25.5	26.5	dB
Variation with frequency referred to 800 Hz	f = 300 and 3400 kHz	ΔG_{vf}	−0.5	±0.2	+0.5	dB
Variation with temperature referred to 800 Hz	I_{line} = 50 mA; T_{amb} = −25 and +75 °C	ΔG_{vT}	–	±0.2	–	dB
Gain adjustment GAS1 and GAS2 (pins 2 and 3)						
Gain variation with R7 connected between pins 2 and 3; transmitting amplifier		ΔG_v	−8	–	+8	dB
Transmitting amplifier output LN (pin 1)						
Output voltage	I_{line} = 15 mA; d_{tot} = 2%	$V_{LN(rms)}$	1.9	2.3	–	V
	d_{tot} = 10%	$V_{LN(rms)}$	–	2.6	–	V
Noise output voltage	I_{line} = 15 mA; R7 = 68 kΩ; pins 7 and 8 open circuit psophometrically weighted (P53 curve)	$V_{no(rms)}$	–	−70	–	dBmp
Receiving amplifier input IR (pin 11)						
Input impedance		$\|Z_i\|$	17	21	25	kΩ
Receiving amplifier outputs QR+ and QR− (pins 4 and 5)						
Output impedance; single-ended		$\|Z_o\|$	–	4	–	Ω
Voltage gain from pin 11 to pin 4 or 5	I_{line} = 15 mA; R4 = 100 kΩ					
single-ended	R_L = 300 Ω	G_v	24	25	26	dB
differential	R_L = 600 Ω	G_v	30	31	32	dB

parameter	conditions	symbol	min.	typ.	max.	unit
Variation with frequency referred to 800 Hz	f = 300 and 3400 Hz	ΔG_{vf}	−0.5	±0.2	+0.5	dB
Variation with temperature referred to 800 Hz	I_{line} = 15 mA T_{amb} = −25 and +75 °C	ΔG_{vT}	–	±0.2	–	dB
Output voltage	I_P = 0 mA; d_{tot} = 2%; R4 = 100 kΩ					
sine-wave drive						
single-ended	R_L = 150 Ω	$V_{o(rms)}$	0.3	0.38	–	V
single-ended	R_L = 450 Ω	$V_{o(rms)}$	0.4	0.52	–	V
differential	C_L = 47 nF					
R_{series} = 100 Ω	f = 3400 Hz	$V_{o(rms)}$	0.8	1.0	–	V
Noise output voltage	I_{line} = 15 mA; R4 = 100 kΩ; pin 11 open circuit psophometrically weighted (P53 curve)					
single-ended	R_L = 300 Ω	$V_{no(rms)}$	–	50	–	μV
differential	R_L = 600 Ω	$V_{no(rms)}$	–	100	–	μV
Gain adjustment GAR (pin 6)						
Gain variation with R4 connected between pins 6 and 5; receiving amplifier		ΔG_v	−8	–	+8	dB
MUTE input (pin 14)						
Input voltage HIGH		V_{IH}	1.5	–	V_{CC}	V
Input voltage LOW		V_{IL}	–	–	0.3	V
Input current		I_{MUTE}	–	8	15	μA
Reduction of voltage gain from MIC+ and MIC− to LN	MUTE = HIGH	ΔG_v	–	70	–	dB
Voltage gain from DTMF to QR+ or QR−	MUTE = HIGH R4 = 100 kΩ					
single-ended load	R_L = 300 Ω	G_v	−21	−19	−17	dB
Power-down input PD (pin 12)						
Input voltage HIGH		V_{IH}	1.5	–	V_{CC}	V
Input voltage LOW		V_{IL}	–	–	0.3	V
Input current		I_{PD}	–	5	10	μA

CHARACTERISTICS (continued)

parameter	conditions	symbol	min.	typ.	max.	unit
Automatic gain control input AGC (pin 17)						
Controlling the gain from IR to QR+/QR− and the gain from MIC+/MIC− to LN; R6 = 110 kΩ (connected between pins 17 and 10)						
Gain control range	I_{line} = 70 mA	$-\Delta G_v$	5.5	5.9	6.3	dB
Highest line current for maximum gain		I_{line}	–	23	–	mA
Lowest line current for lowest gain		I_{line}	–	61	–	mA
Reduction of gain between I_{line} = 15 mA and I_{line} = 35 mA		$-\Delta G_v$	1.0	1.5	2.0	dB

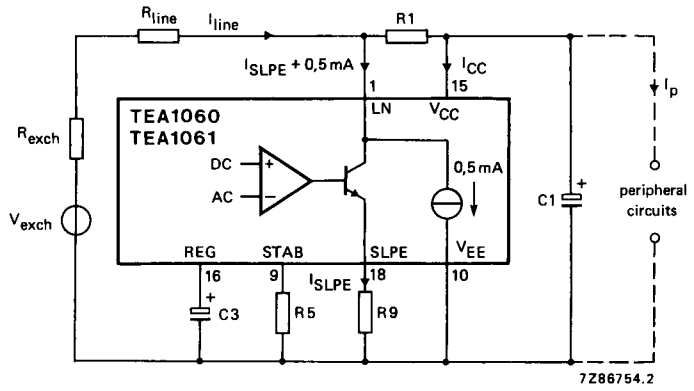
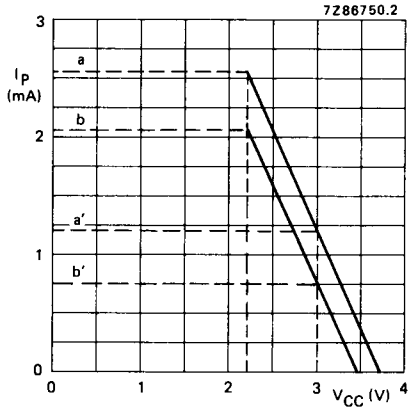


Fig.4 Supply arrangement.



I_{line} = 15 mA at
V_{LN} = 4.45 V;
R1 = 620 Ω, R9 = 20 Ω

Fig.5 Maximum current Ip available from V_{CC} for external (peripheral) circuitry with $V_{CC} > 2.2$ V and $V_{CC} > 3$ V. Curves (a) and (a') are valid when the receiving amplifier is not driven or when MUTE = HIGH. Curves (b) and (b') are valid when MUTE = LOW and the receiving amplifier is driven. $V_{o(rms)}$ = 150 mV, R_L = 150 Ω (asymmetrical).

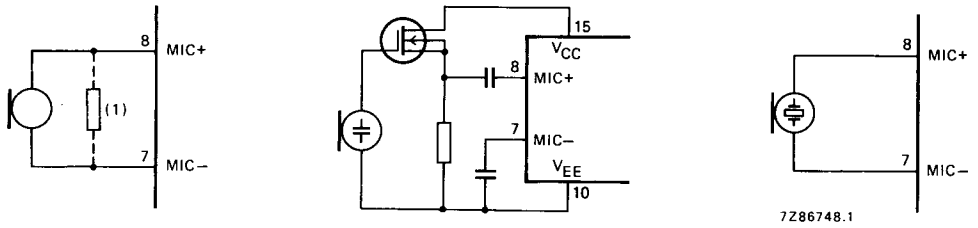


Fig.6 Alternative microphone arrangements: (a) magnetic or dynamic microphone for TEA1060, the resistor marked (1) may be connected to lower the terminating impedance, (b) electret microphone and (c) piezoelectric microphone for TEA1061.

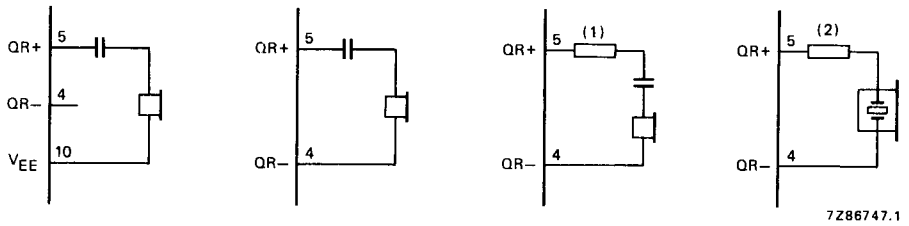


Fig.7 Alternative receiver arrangements: (a) dynamic earpiece with less than 450 Ω impedance, (b) dynamic earpiece with more than 450 Ω impedance, (c) magnetic earpiece. The resistor marked (1) may be connected to prevent distortion [inductive load (d)] piezoelectric earpiece. The resistor marked (2) is required to increase the phase margin (capacitive load).

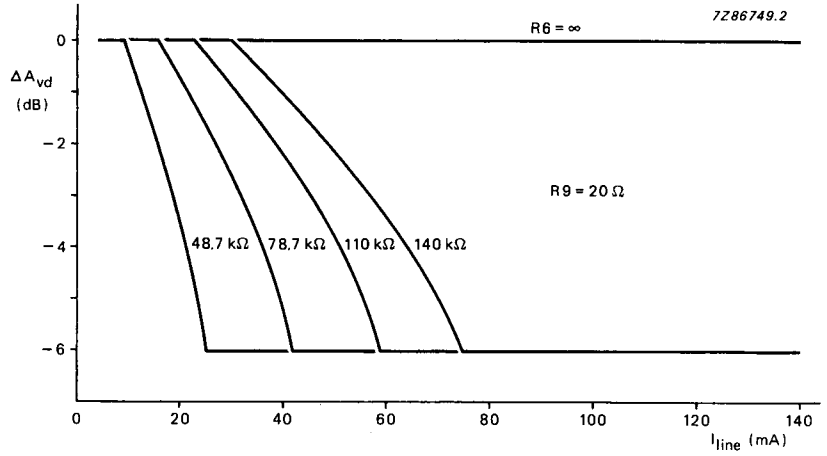


Fig.8 Variation of gain with line current with R6 as a parameter.

Table 1 Values of resistor R6 for optimum line loss compensation, for various usual values of exchange supply voltage V_{exch} and exchange feeding bridge resistance R_{exch}; R9 = 20 Ω.

		R_{exch} (Ω)			
		400	600	800	1000
		R6 (kΩ)			
V_{exch} (V)	24	61.9	48.7	X	X
	36	100	78.7	68	60.4
	48	140	110	93.1	82
	60	X	X	120	102

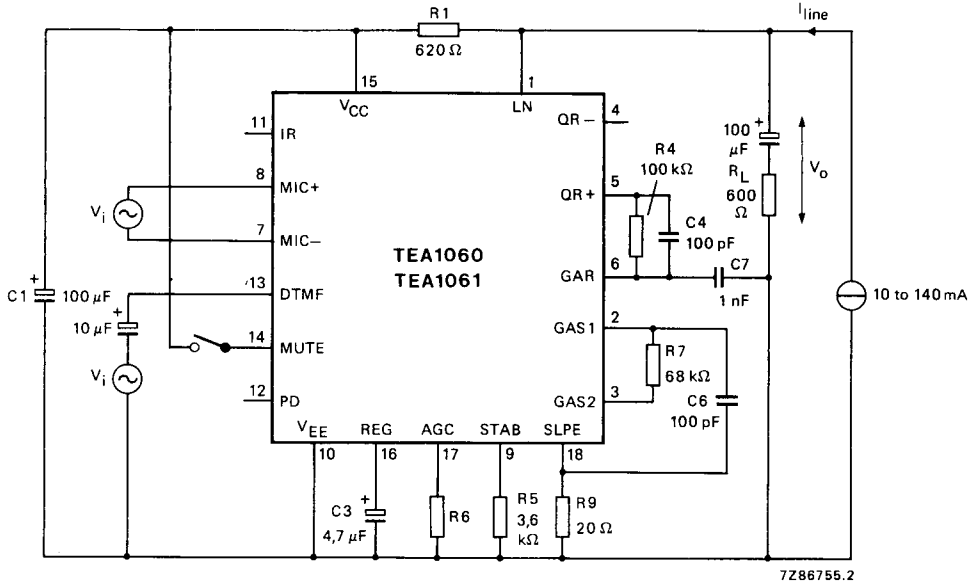


Fig.9 Test circuit for defining voltage gain of MIC+, MIC– and DTMF inputs. Voltage gain is defined as; $G_v = 20 \log |V_o/V_i|$. For measuring the gain from MIC+ and MIC– the MUTE input should be LOW or open circuit. For measuring the DTMF input MUTE should be HIGH. Inputs not under test should be open circuit.

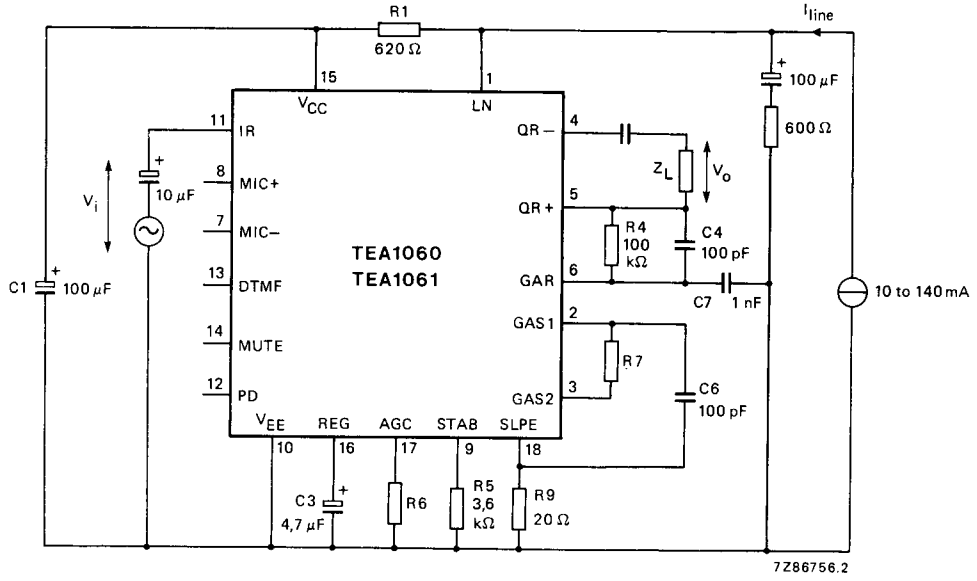


Fig.10 Test circuit for defining voltage gain of the receiving amplifier. Voltage gain is defined as; $G_v = 20 \log |V_o/V_i|$.

APPLICATION INFORMATION

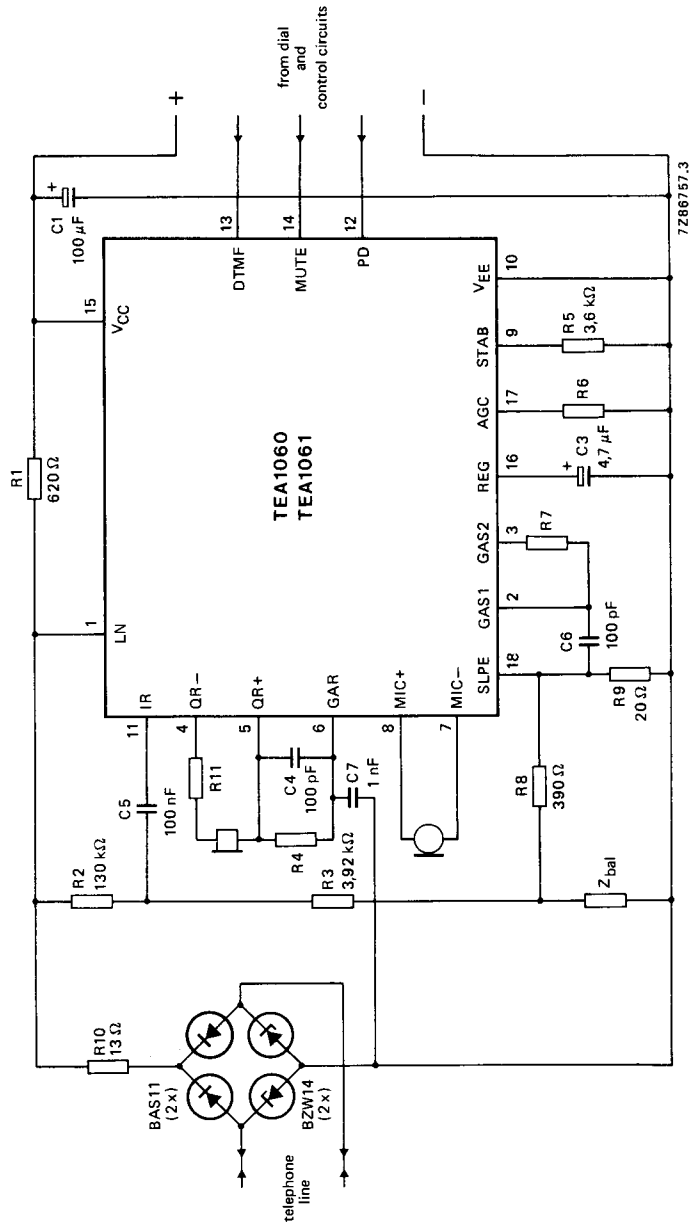


Fig.11 Typical application of the TEA1060 or TEA1061, shown here with a piezoelectric earpiece and DTMF dialling. The bridge to the left and R10 limit the current into the circuit and the voltage across the circuit during line transients. Pulse dialling or register recall require a different protection arrangement.

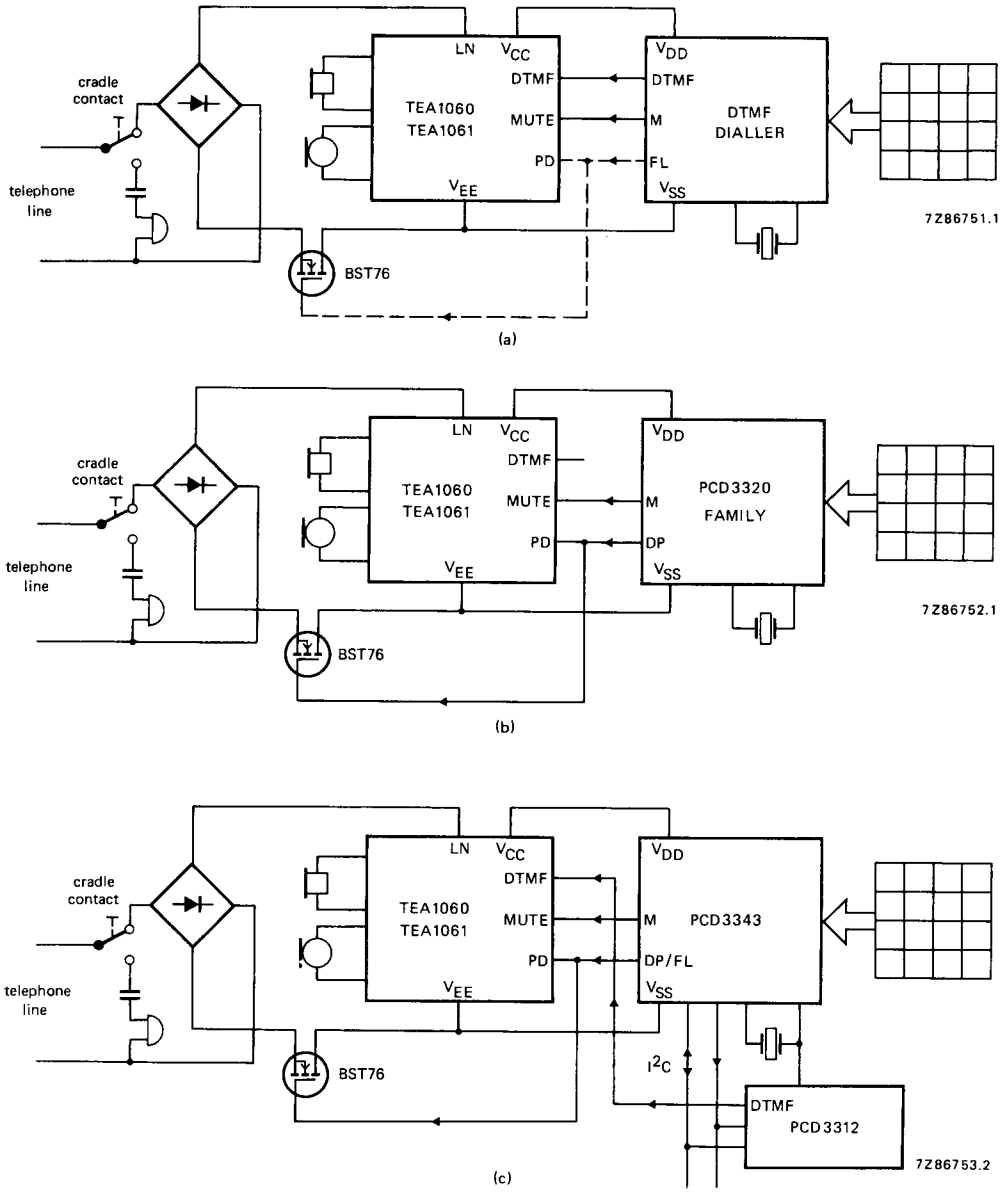


Fig.12 Typical applications of the TEA1060 or TEA1061 (simplified): (a) DTMF set with a CMOS DTMF dialling circuit, the dashed lines show an optional flash (register recall by timed loop break); (b) Pulse dial set with the one of the PCD3320 family of CMOS interrupted current-loop dialling circuits; (c) Dual-standard (pulse and DTMF) feature phone with the PCD3343 CMOS telephone controller and the PCD3312 CMOS DTMF generator with I^2C-bus.