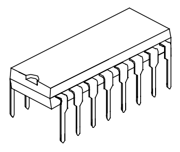
LOW VOLTAGE TELEPHONE TRANSMISSION CIRCUIT WITH DIALLER INTERFACE



DIP-16

DESCRIPTION

The UTC1062 is a bipolar integrated circuit performing all speech and line interface function required in the fully electronic telephone sets. It performs electronic switching between dialing speech. The circuit is able to operate down to d.c. line voltage of 1.6v (with reduced performance) to facilitate the use of more telephone sets in parallel.

FEATURES

* Low d.c. line voltage; operates down to 1.6V (excluding polarity guard)
* Voltage regulator with adjustment static resistance
* Provides supply with limited current for external circuitry
* Symmetrical high-impedance inputs (64kΩ) for dynamic, magnetic or piezoelectric microphones
* Asymmetrical high-impedance inputs (32kΩ) for electric microphones
* DTMF signal input with confidence tone
* Mute input for pulse or DTMF dialing
* Receiving amplifier for several types of earphones
* Large amplification setting range on microphone and ear piece amplifiers
* Line loss compensation facility , line current dependent (microphone and ear piece amplifiers)
* Gain control adaptable to exchange supply
* Possibility to adjust the d.c. line voltage

QUICK REFERENCE DATA

Line voltage at I_{line}=15mA	V_{LN}	typ. 3.8 V
Line current operating range[pin1] normal operation with reduced performance	 I_{line} I_{line}	 11 to 140 mA 1 to 11 mA
Internal supply current	I_{CC}	typ. 1mA
Supply current for peripherals at I_{line}=15 mA mute input HIGH Vcc>2.2V Vcc>2.8V	 I_p I_p	 typ. 1.8mA typ. 0.7mA
Voltage amplification range microphone amplifier receiving amplifier	 A_{VD} A_{VD}	 44 to 52 dB 20 to 39 dB
Line loss compensation Amplification control range Exchange supply voltage range Exchange feeding bridge resistance range	 A_{VD} V_{exch} R_{exch}	 Typ. 6 dB 36 to 60V 400 to 1000Ω
Operating ambient temperature range	T_{amb}	-25 to +75°C

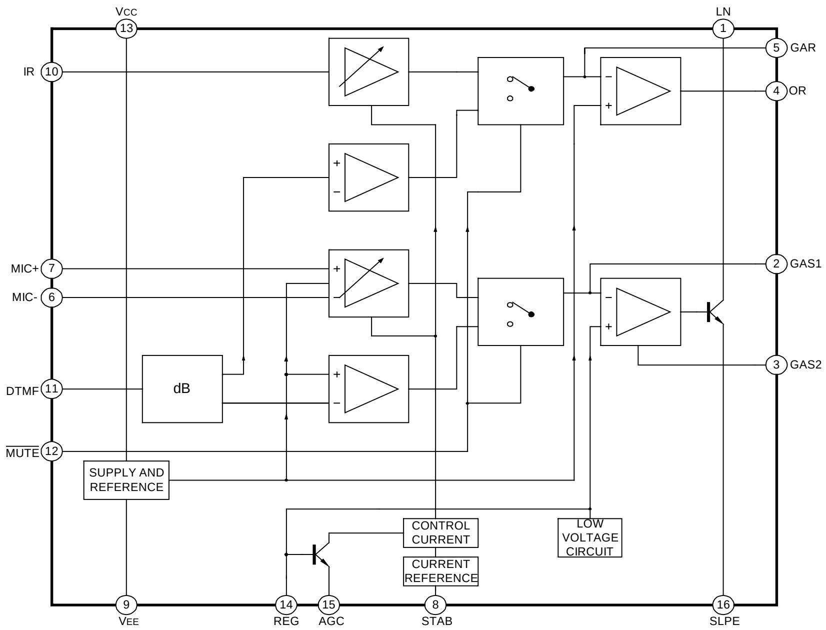
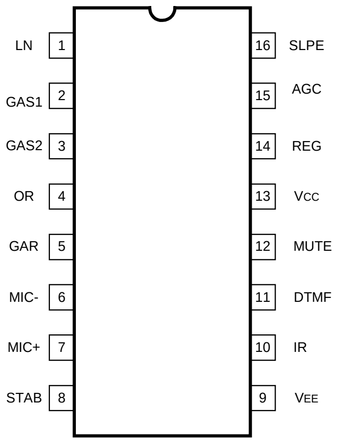


Fig.1 Block Diagram



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

Fig.2 Pining Diagram

RATING LIMITING VALUES (In accordance with the Absolute Maximum System)

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/5s	R10=13Ω R9=20Ω (see Fig.15)	V_{LN}	-	28	V
Line current (1)	R9=20Ω	I_{line}	-	140	mA
Voltage on all other pins		V_i $-V_i$	- -	V_{CC}+0.7 0.7	V V
Total power dissipation(2)	R9=20Ω	P_{tot}	-	640	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 Figs 6).
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 Rth j-a = 75K/W

ELECTRONICAL CHARACTERISTICS

(Iline=11 to 140mA;V_{EE}=0V;f=800Hz;T_{amb}=25°C;unless otherwise specified)

parameter	conditions	symbol	min.	typ.	max.	unit
Supply; LN and VCC(pins 1 and 13)						
Voltage drop over circuit, between LN and V_{EE}	MIC inputs open					
	I_{line}=1mA	V_{LN}	-	1.6	-	V
	I_{line}=4mA	V_{LN}	-	1.9	-	V
	I_{line}=15mA	V_{LN}	3.55	4.0	4.25	V
	I_{line}=100mA	V_{LN}	4.9	5.7	6.5	V
	I_{line}=140mA	V_{LN}	-	-	7.5	V
Variation with temperature	I_{line}=15mA	$\Delta V_{LN}/\Delta T$	-	-0.3	-	mV/K
Voltage drop over circuit, between LN and VEE with external resistor R_{VA}	I_{line}=15mA R_{VA}(LN to REG) =68kΩ		-	3.5	-	V
	I_{line}=15mA R_{VA}(REG to SLPE) =39kΩ		-	4.5	-	V
Supply current	V_{CC}=2.8V	I_{CC}	-	0.9	1.35	mA
Supply voltage available for peripheral circuitry	I_{line}=15mA MUTE=HIGH					
	I_p=1.2mA	V_{CC}	2.2	2.7	-	V
	I_p=0mA	V_{CC}	-	3.4	-	V

ELECTRONICAL CHARACTERISTICS (continued)

parameter	conditions	symbol	min.	typ.	max.	unit
Microphone inputs MIC+ and MIC- (pins6 and 7)						
Input impedance (differential) between MIC- and MIC+		$\|Z_i\|$	–	64	–	kΩ
Input impedance (sigle-ended) MIC- or MIC+ to V_{EE}		$\|Z_i\|$	–	32	–	kΩ
Common mode rejection ratio		k_{CMR}	–	82	–	dB
Voltage gain MIC+ or MIC- to LN	I_{line}=15mA R7=68kΩ	G_v	50.5	52.0	53.5	dB
Gain variation with frequency at f=300Hz and f=3400Hz	w.r.t.800Hz	ΔG_{vf}	–	±0.2	–	dB
Gain variation with temperature At−25°C and +75°C	w.r.t.25°C without R6; I_{line}=50mA	ΔG_{vT}	–	±0.2	–	dB
Dual-tone multi-frequency input DTMF (pin 11)						
Input impedance		$\|Z_i\|$	–	20.7	–	kΩ
Voltage gain from DTMF to LN	I_{line}=15mA R7=68kΩ	G_v	24.0	25.5	27.0	dB
Gain variation with frequency at f=300Hz and f=3400Hz	w.r.t.800Hz	ΔG_{vf}	–	±0.2	–	dB
Gain variation with temperature At−25°C and +75°C	w.r.t.25°C I_{line}=50mA	ΔG_{vT}	–	±0.2	–	dB
Gain adjustment GAS1 and GAS2 (pin2 and 3)						
Gain variation of the transmitting						
amplifier by varying R7 between GAS1 and GAS2		ΔG_v	−8	–	0	dB
Sending amplifier output LN(pin 1) Output voltage	I_{line}=15mA THD=10%	V_{LN}(rms)	1.7	2.3	–	V
	I_{line}=4mA THD=10%	V_{LN}(rms)	–	0.8	–	V
Noise output voltage	I_{line}=15mA; R7=68kΩ; 200Ω between MIC- and MIC+; psophometrically weighted	V_{NO}(rms)	–	−69	–	dB
Receiving amplifier input IR (pin10)						
Input impedance		$\|Z_i\|$	–	21	–	kΩ

ELECTRONICAL CHARACTERISTICS (continued)

parameter	conditions	symbol	min.	typ.	max.	unit
Receiving amplifier output OR (pin4)						
Output impedance		$\|Z_o\|$	—	4	—	Ω
Voltage gain from IR to OR	I_{line}=15mA; R_L(from pin 9 to pin 4)=300Ω	G_v	29.5	31	32.5	dB
Gain variation with frequency at f=300Hz and f=3400Hz	w.r.t.800Hz	ΔG_{vf}	—	±0.2	—	dB
Gain variation with temperature At −25°C and +75°C	w.r.t.25°C without R6 I_{line}=50mA	ΔG_{vT}	—	±0.2	—	dB
Output voltage	sine wave drive; I_p=0mA;THD=2% R4=100kΩ I_{line}=15mA R_L=150Ω	V_O(rms)	0.22	0.33	—	V
	R_L=450Ω	V_O(rms)	0.3	0.48	—	V
Output voltage	THD=10% R4=100kΩ R_L=150Ω I_{line}=4mA	V_O(rms)	—	15	—	mV
Noise output voltage	I_{line}=15mA R4=100kΩ IR open-circuit psophometrically weighted R_L=300Ω	V_{NO}(rms)	—	50	—	μV
Gain adjustment GAR(pin 5)						
Gain variation of receiving amplifier achievable by varying R4 between GAR and OR		ΔG_v	−11	—	0	dB
MUTE input (pin 12)						
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 gain						
MIC+ or MIC− to OR	MUTE=HIGH	ΔG_v	—	70	—	dB
Voltage gain from DTMF to OR	MUTE=HIGH R4=100kΩ R_L=300Ω	G_v	—	−19	—	dB
Automatic gain control input AGC pin(15)						
Controlling the gain from IR to OR and the gain from MIC+/MIC- to LN;R6 between AGC and VEE Gain control range	R6=110kΩ I_{line}=70mA	ΔG_v	—	−5.8	—	dB

ELECTRONICAL CHARACTERISTICS (continued)

parameter	conditions	symbol	min.	typ.	max.	unit
Highest line current for maximum gain		I_{line}	—	23	—	mA
Minimum line current for minimum gain		I_{line}	—	61	—	mA

FUNCTIONAL DESCRIPTION

Supply: VCC,LN,SLPE,REG and STAB

Power for the UTC1062 and its peripheral circuits is usually obtained from the telephone line. The IC supply voltage is derived from the line via a dropping resistor and regulated by the UTC1062,The supply voltage Vcc may also be used to supply external circuits e.g. dialing and control circuits. Decoupling of the supply voltage is performed by a capacitor between Vcc and V_{EE} while the internal voltage regulator is decoupled by a capacitor between REG and V_{EE}.

The DC current drawn by the device will vary in accordance with varying values of the exchange voltage(V_{exch}), the feeding bridge resistance(R_{exch}) and the DC resistance of the telephone line(R_{line}).

The UTC1062 has an internal current stabilizer operating at a level determined by a 3.6kΩ resistor connected between STAB and VEE(see Fig.8). When the line current(I_{line}) is more than 0.5 mA greater than the sum of the IC supply current (Icc) and the current drawn by the peripheral circuitry connected to V_{CC}(I_p) the excess current is shunted to V_{EE} via LN.

The regulated voltage on the line terminal(V_{LN}) can be calculated as:

$V_{LN}=V_{ref}+I_{SLPE}*R9$ or;

$V_{LN}=V_{ref}+[(I_{line}-I_{CC}-0.5*10^{-3}A)-I_p]*R9$

where: V_{ref} is an internally generated temperature compensated reference voltage of 3.7V and R9 is an external resistor connected between SLPE and V_{EE}. In normal use the value of R9 would be 20Ω. Changing the value of R9 will also affect microphone gain, DTMF gain, in control characteristics, ide-tone level, maximum output swing on LN and the dc characteristics(especially at the lower voltages).

Under normal conditions, when $I_{SLPE} \geq I_{CC}+0.5mA+I_p$, the static behavior of the circuit is that of a 3.7V regulator diode with an internal resistance equal to that of R9.In the audio frequency range the dynamic impedance is largely determined by R1.Fig.3 shows the equivalent impedance of the circuit.

Microphone inputs(MIC+ and MIC-) and gain pins (GAS1 and GAS2)

The UTC1062 has symmetrical inputs. Its input impedance is 64kΩ (2*32kΩ) and its voltage gain is typically 52 dB (when R7=68kΩ.see Fig.13). Dynamic, magnetic, piezoelectric or electret (with built-in FET source followers) can be used. Microphone arrangements are illustrated in Fig.10. The gain of the microphone amplifier can be adjusted between 44dB and 52dB to suit the sensitivity of the transducer in use. The gain is proportional to the value of R7 which is connected between GAS1 and GAS2. Stability is ensured by the external capacitors, C6 connected between GAS1 and SLPE and C8 connected between GAS1 and VEE. The value of C6 is 100pF but this may be increased to obtain a first-order low-pass filter. The value of C8 is 10 times the value of C6. The cut-off frequency corresponds to the time constant R7*C6.

Mute input(MUTE)

A HIGH level at MUTE enables DTMF input and inhabits the microphone inputs and the receiving amplifier inputs; a LOW level or an open circuit does the reverse. Switching the mute input will cause negligible click is at the telephone outputs and on the line. In case the line current drops below 6mA(parallel operation of more sets) the circuit is always in speech condition independent of the DC level applied to the MUTE input.

Dual-tone multi-frequency input(DTMF)

When the DTMF input is enabled dialing tones may be sent onto the line. The voltage gain from DTMF to LN is typically 25.5dB(when R7=68kΩ) and varies with R7 in the same way as the microphone gain. The signaling tones can be heard in the ear piece at a low level(confidence tone).

Receiving Amplifier (IR,OR and GAR)

The receiving amplifier has one input(IR) and a non-inverting output(OR). Ear piece arrangements are illustrated in Fig.11. The IR to OR gain is typically 31dB (when R4=100kΩ). It can be adjusted between 20 and 31dB to match the sensitivity of the transducer in use. The gain is set with the value of R4 which is connected between GAR and OR. The overall receive gain, between LN and OR, is calculated by substracting the anti-sidetone network attenuation (32dB) from the amplifier gain. Two external capacitors, C4 and C7, ensure stability. C4 is normally 100pF and C7 is 10 times the value of C4. The value of C4 may be increased to obtain a first-order low-pass filter. The cut-off frequency will depend on the time constant R4*C4.

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 peak to RMS ratio is higher.

Automatic gain control input(AGC)

Automatic line loss compensation is achieved by connecting a resistor(R6) between AGC and V_{EE}. The 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 5.8dB which corresponds to a line length of 5km for a 0.5mm diameter twisted pair copper cable with a DC resistance of 176Ω/km and average attenuation of 1.2dB/km. Resistor R6 should be chosen in accordance with the exchange supply voltage and its feeding bridge resistance(see Fig.12 and Table 1). The ratio of start and stop currents of the AGC curve is independent of the value of R6. If no automatic line loss compensation is required the AGC may be left open-circuit. The amplifier, in this condition, will give their maximum specified gain.

Side-tone suppression

The anti-sidetone network, R1//Z_{line}, R2, R3, R8, R9 and Z_{bal},(see Fig.4) suppresses the transmitted signal in the ear piece. Compensation is maximum 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 when R8/Z_{bal}l <R3. To obtain optimum side-tone suppression condition(b) has to be fulfilled which results in: Z_{bal}=(R8/R1) Z_{line}=k*Z_{line} where k is a scale factor; k=(R8/R1). The scale factor (k), dependent on the value of R8, is chosen to meet following criteria:

(a) Compatibility with a standard capacitor from the E6 or E12 range for Z_{bal},

(b) | Z_{bal}//R8 | <R3 fulfilling condition (a) and thus ensuring correct anti-sidetone bridge operation,

(c) | Z_{bal}+R8 | >R9 to avoid influencing the transmitter gain.

In practice Z_{line} varies considerably with the type and length. The value chosen for Z_{bal} should therefore be for an average line length thus giving optimum setting for short or long lines.

Example

The balance impedance Z_{bal} at which the optimum suppression is present can be calculated by: Suppose Z_{line} = 210Ω+(1265Ω//140nF) representing a 5km line of 0.5 mm diameter, copper, twisted pair cable matched to 600Ω (176Ω/km;38nF/km). When k=0.64 then R8=390Ω,Z_{bal}=130Ω+(820Ω//220nF).

At line currents below 9mA the internal reference voltage is automatically adjusted to a lower value(typically 1.6V at 1mA) This means that more sets can be operated in parallel with DC line voltages (excluding the polarity guard) down to an absolute minimum voltage of 1.6V. With line currents below 9mA the circuit has limited sending and receiving levels. The internal reference voltage can be adjusted by means of an external resistor(R_{VA}). This resistor when connected between LN and REG will decrease the internal reference voltage and when connected between REG and SLPE will increase the internal reference voltage.

Current(I_P) available from V_{CC} for peripheral circuits depends on the external components used. Fig.9 shows this current for V_{CC}>2.2V. If MUTE is LOW when the receiving amplifier is driven the available current is further reduced. Current availability can be increased by connecting the supply IC(1081) in parallel with R1, as shown in Fig.16(c), or, by increasing the DC line voltage by means of an external resistor(R_{VA}) connected between REG and SLPE..

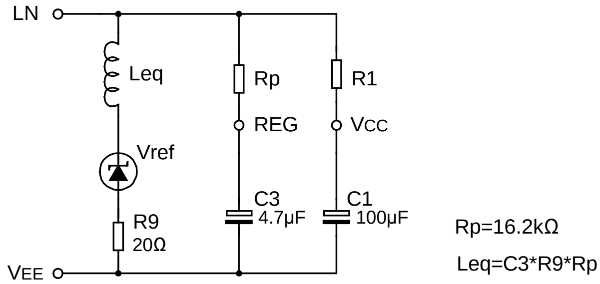


Fig.3 Equivalent impedance circuit

The anti-sidetone network for the 1062 family shown in Fig.4 attenuates the signal received from the line by 32 dB before it enters the receiving amplifier. The attenuation is almost constant over the whole audio frequency range. Fig.5 shows a conventional Wheat stone bridge anti-sidetone circuit that can be used as an alternative. Both bridge types can be used with either resistive or complex set impedance.

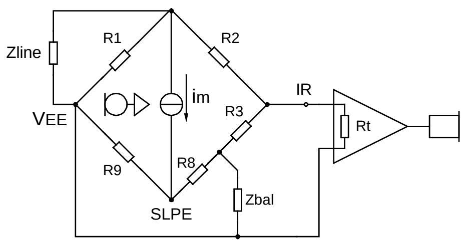


Fig 4 Equivalent circuit of UTC1062 anti-sidetone bridge

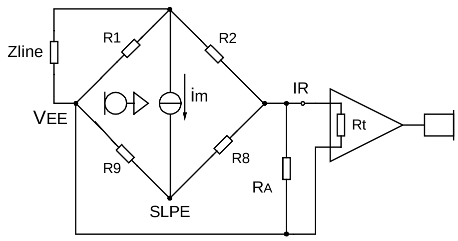


Fig 5 Equivalent circuit of an anti-sidetone network in a wheat stone bridge configuration

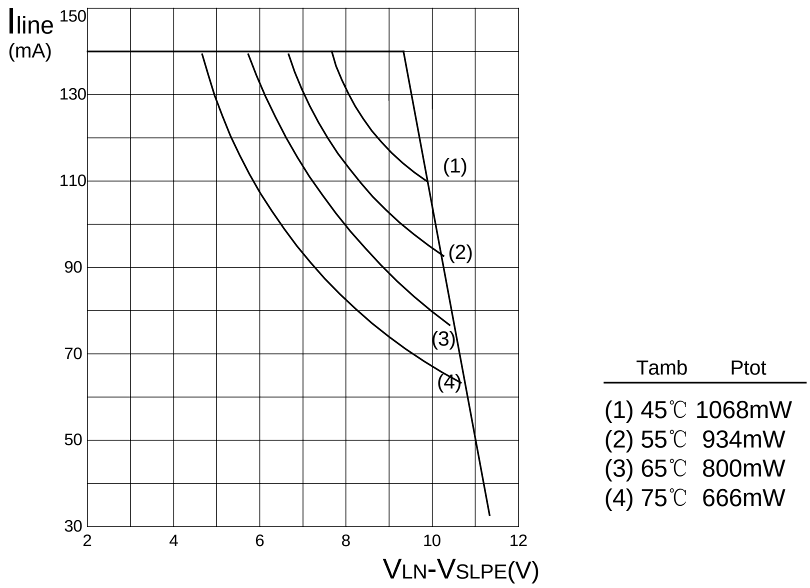


Fig.6 UTC1062 safe operating area

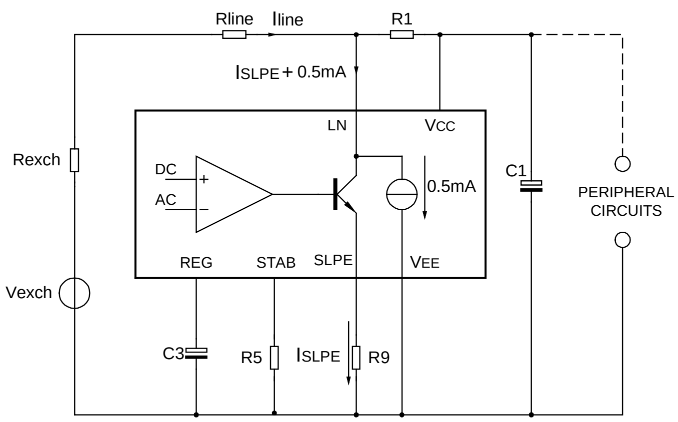


Fig.8 Supply arrangement

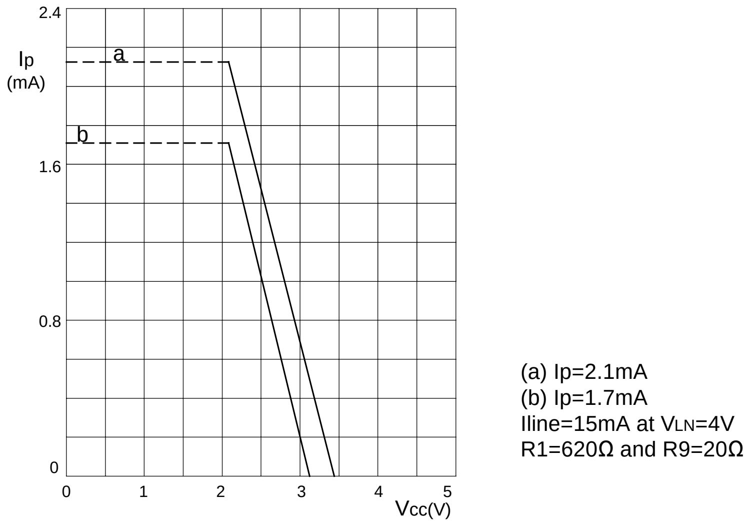
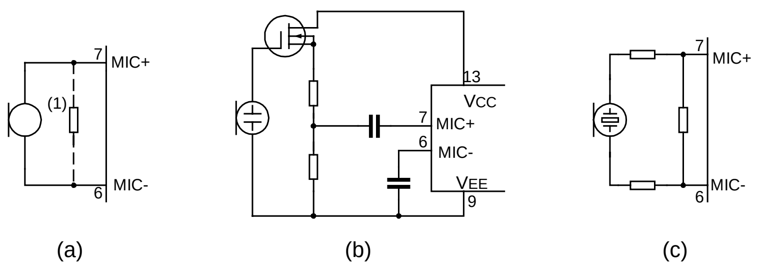


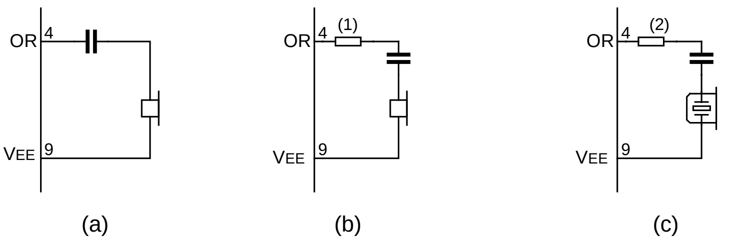
Fig.9 Typical current Ip available from Vcc peripheral circuitry with Vcc>=2.2V.

curve (a) is valid when the receiving amplifier is not driven or when MUTE =HIGH .curve(b) is valid when MUTE=LOW and the receiving amplifier is driven; Vo(rms)=150mV,R_L=150Ω.The supply possibilities can be increased simply by setting the voltage drop over the circuit V_{LN} to a high value by means of resistor R_{VA} connected between REG and SLPE.



(a) Magnetic or dynamic microphone. The resistor marked(1) may be connected to decrease the terminating impedance.
(b) Electret microphone.
(c) Piezoelectric microphone.

Fig. 10 Alternative microphone arrangement



(a) Dynamic ear piece.
(b) Magnetic ear piece. The resistor marked(1) may be connected to prevent distortion(inductive load)
(c) Piezoelectric ear piece. The ear piece marked(2) is required to increase the phase margin (capacitive load)

Fig.11 Alternative receiver arrangement

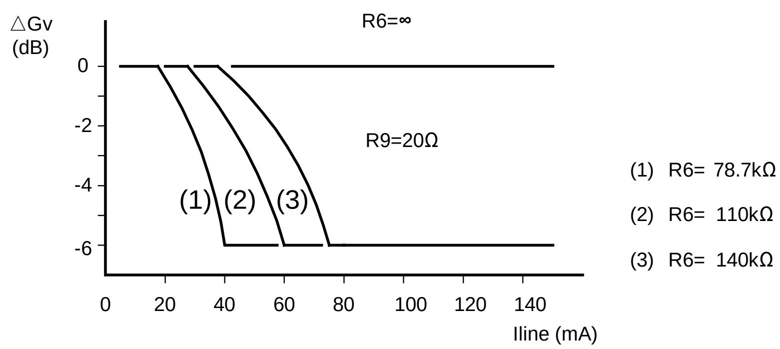


Fig.12 Variation of gain with line current, with R6 as a parameter.

		Rexch(Ω)			
		400	600	800	1000
		R6(kΩ)			
Vexch(V)	36	100	78.7	×	×
	48	140	110	93.1	82
	60	×	×	120	102

Table 1 Values of resistor R6 for optimum line loss compensation, for various usual values of exchange supply voltage(Vexch) and exchange feeding bridge resistance(Rexch);R9=20Ω.

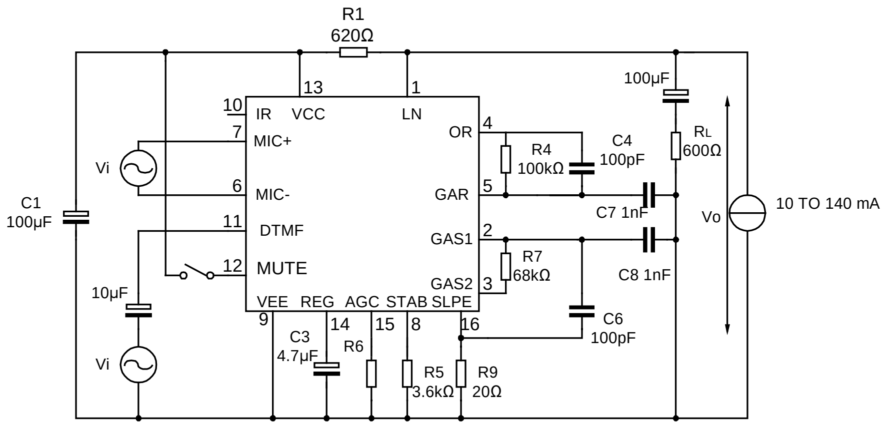


Fig.13 Test circuit defining voltage gain of MIC+,MIC- and DTMF inputs. Voltage gain is defined as : $G_V=20*\log(|V_O/V_i|)$.For measuring the gain from MIC+ and MIC- the MUTE input should be LOW or open-circuit, for measuring the DTMF input MUTE should be HIGH .Inputs not under test should be open-circuit.

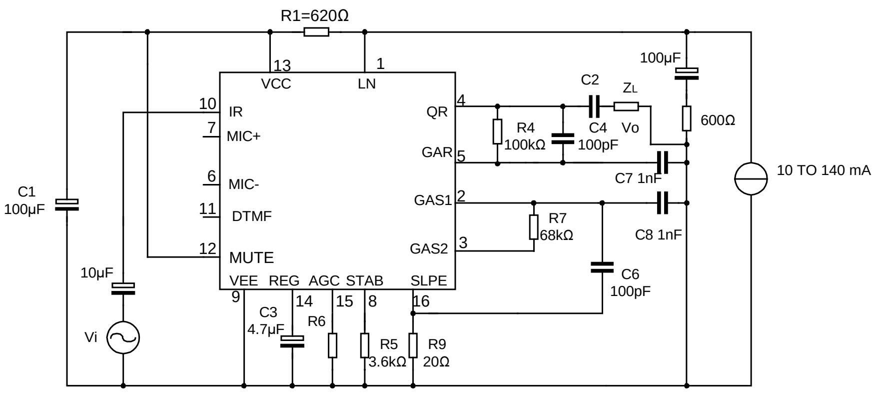


Fig.14 Test circuit for defining voltage gain of the receiving amplifier. Voltage gain is defined as:
$G_V=20*\log(|V_O/V_i|)$.

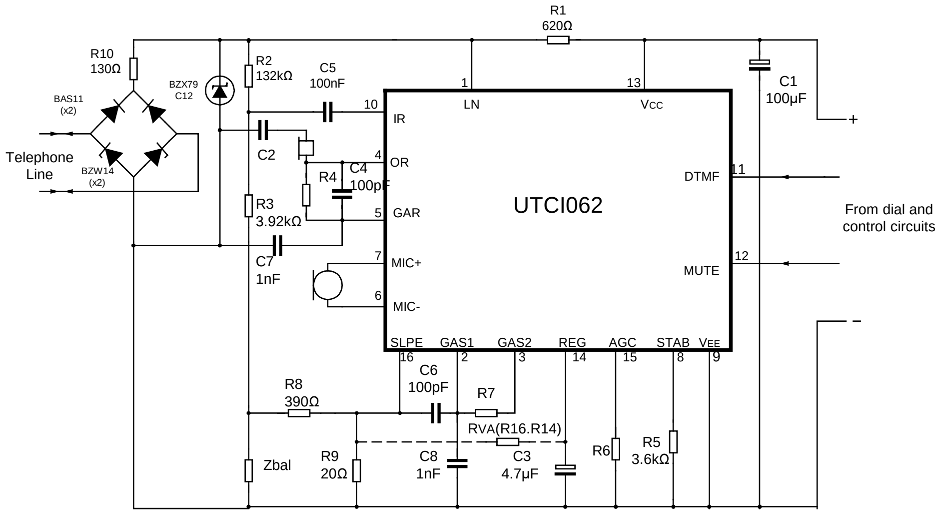


Fig.15 Typical application of the UTC1062 ,shown here with a piezoelectric ear piece and DTMF dialing. The bridge to the left ,the Zener diode and R10 limit the current into the circuit and the voltage across the circuit during line transients. Pulse dialing or register recall required a different protection arrangement.
The DC line voltage can be set to a higher value by resistor RVA(REG to SLPE).

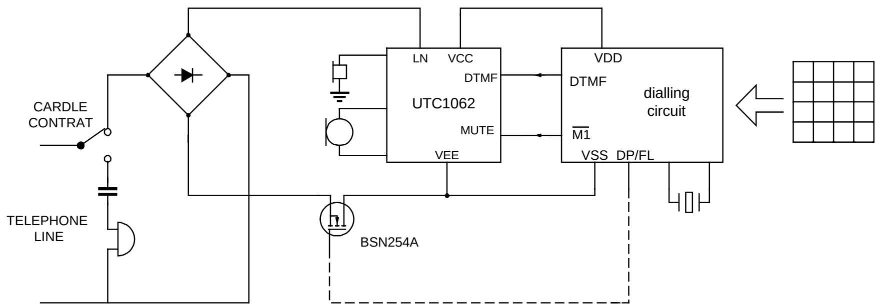


Fig.16 Typical applications of the UTC1062 (simplified)
The dashed lines show an optional flash (register recall by timed loop break).