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## Features

- DC Characteristic Adjustable
- Transmit and Receive Gain Adjustable
- Symmetrical Input of Microphone Amplifier
- Anti-clipping in Transmit Direction
- Automatic Line-loss Compensation
- Symmetrical Output of Earpiece Amplifier
- Built-in Ear Protection
- DTMF and MUTE Input
- Adjustable Sidetone Suppression Independent of Sending and Receiving Amplification
- Speech Circuit with Two Sidetone Networks
- Built-in Line Detection Circuit
- Integrated Amplifier for Loud-hearing Operation
- Anti-clipping for Loudspeaker Amplifier
- Improved Acoustical Feedback Suppression
- Power Down
- Voice Switch
- Tone Ringer Interface with DC/DC Converter
- Zero Crossing Detection
- Common Speaker for Loud-hearing and Tone Ringer
- Supply Voltages for all Functional Blocks of a Subscriber Set
- Integrated Transistor for Short-circuiting the Line Voltage
- Answering Machine Interface
- Operation Possible from 10 mA Line Currents
- Filters against EMI on Critical I/O

## Applications

- Feature Phone
- Answering Machine
- Fax Machine
- Speaker Phone

## Benefits

- Savings of One Piezoelectric Transducer
- Complete System Integration of Analog Signal Processing on One Chip
- Very Few External Components
- Fewer Components for EMI Protection



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**Monolithic  
Integrated  
Feature Phone  
Circuit EMI  
Improved**

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**U4090B-P**

Rev. 4741C-CORD-11/05



## 1. Description

The microcontroller-controlled telephone circuit U4090B-P is a linear integrated circuit for use in feature phones, answering machines and fax machines. It contains the speech circuit, tone ringer interface with DC/DC converter, sidetone equivalent and ear protection rectifiers. The circuit is line powered and contains all components necessary for amplification of signals and adaptation to the line.

An integrated voice switch with loudspeaker amplifier allows loud-hearing or hands-free operation. With an anti-feedback function, acoustical feedback during loud-hearing can be reduced significantly. The generated supply voltage is suitable for a wide range of peripheral circuits.

**Figure 1-1.** Block Diagram

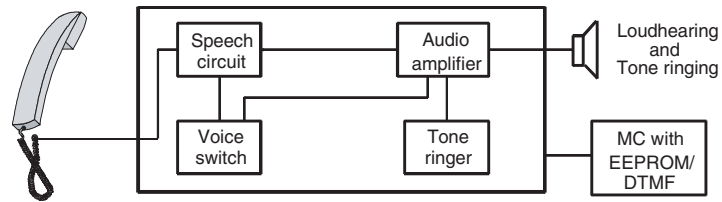
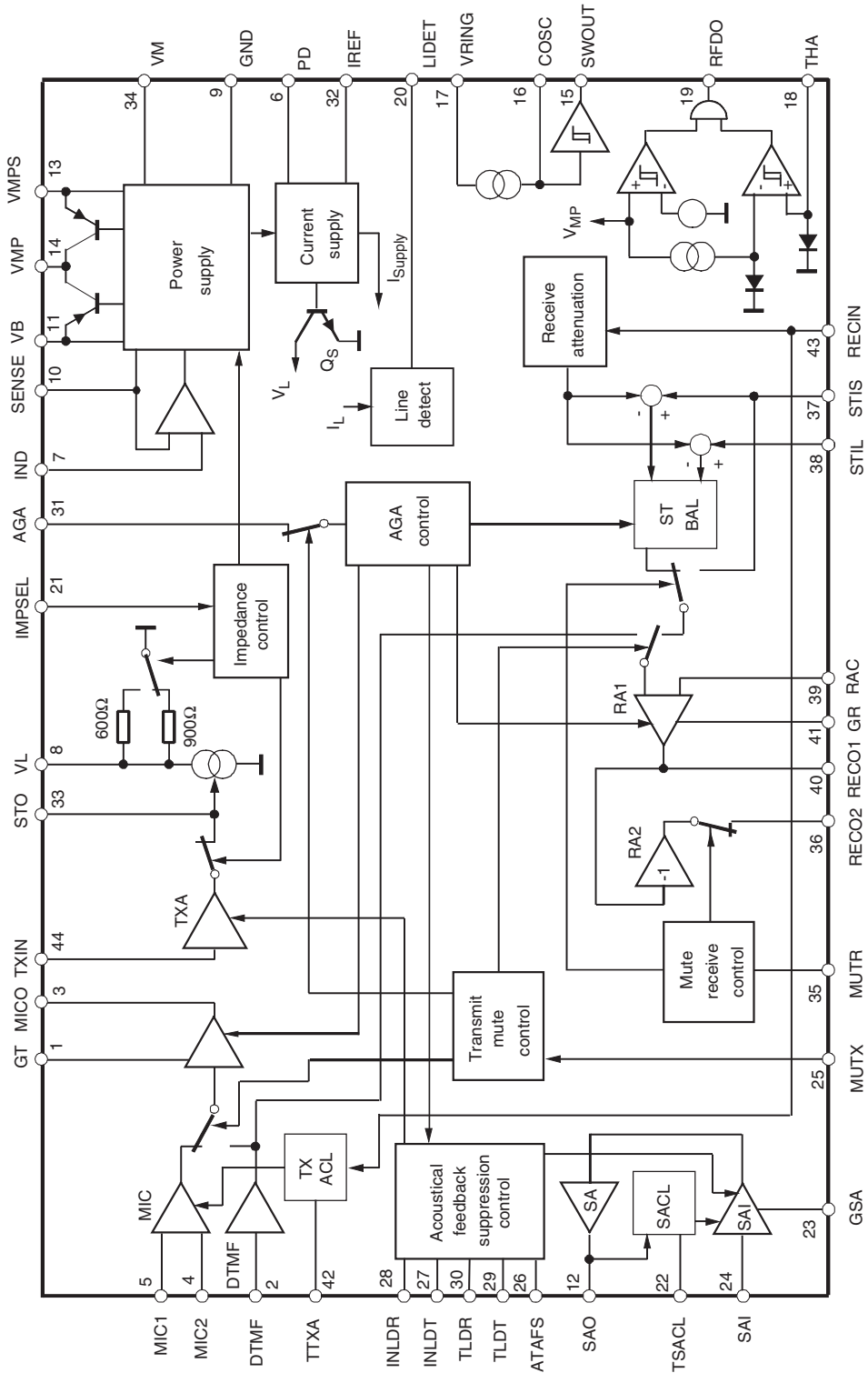
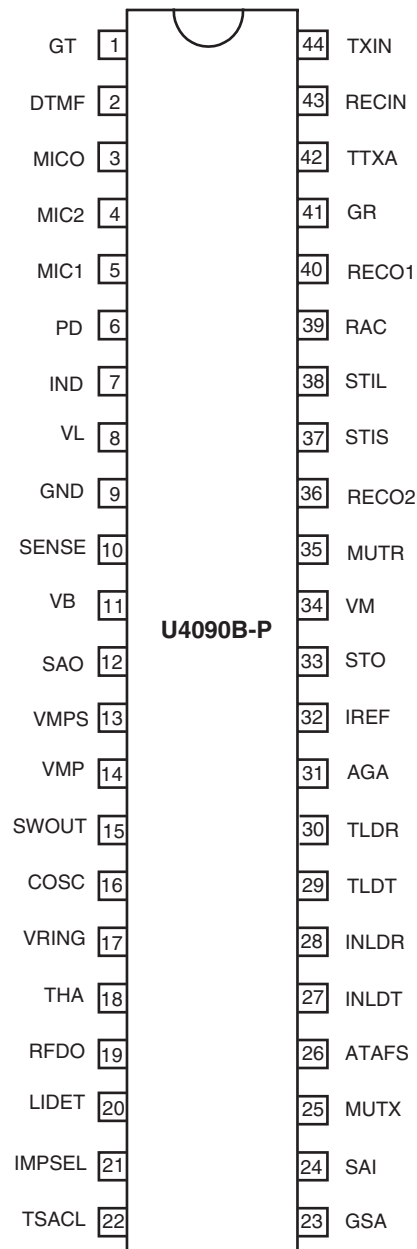


Figure 1-2. Detailed Block Diagram



## 2. Pin Configuration

Figure 2-1. Pinning SSO44



**Table 2-1.** Pin Description

Pin	Symbol	Function
1	GT	A resistor from this pin to GND sets the amplification of the microphone and DTMF signals, the input amplifier can be muted by applying VMP to $G_T$
2	DTMF	Input for DTMF signals, also used for the answering machine and hands-free input
3	MICO	Output of microphone preamplifier
4	MIC2	Non-inverting input of microphone amplifier
5	MIC1	Inverting input of microphone amplifier
6	PD	Active high input for reducing the current consumption of the circuit, simultaneously $V_L$ is shorted by an internal switch
7	IND	The internal equivalent inductance of the circuit is proportional to the value of the capacitor at this pin, a resistor connected to ground may be used to reduce the DC line voltage
8	VL	Line voltage
9	GND	Reference point for DC- and AC-output signals
10	SENSE	A small resistor (fixed) connected from this pin to $V_L$ sets the slope of the DC characteristic and also effects the line-length equalization characteristics and the line current at which the loudspeaker amplifier is switched on
11	VB	Unregulated supply voltage for peripheral circuits (voice switch), limited to typically 7V
12	SAO	Output of loudspeaker amplifier
13	VMPS	Unregulated supply voltage for microcontroller, limited to 6.3V
14	VMP	Regulated supply voltage of 3.3V for peripheral circuits (especially microprocessors), minimum output current: 2 mA (ringing) 4 mA (speech mode)
15	SWOUT	Output for driving external switching transistor
16	COSC	40-kHz oscillator for ringing power converter
17	VRING	Input for ringing signal protected by internal Zener diode
18	THA	Threshold adjustment for ringing frequency detector
19	RFDO	Output of ringing frequency detector
20	LIDET	Line detect; output is low when the line current is more than 15 mA
21	IMPSEL	Control input for selection of line impedance 1. 600 $\Omega$ 2. 900 $\Omega$ 3. Mute of second transmit stage (TXA); also used for indication of external supply (answering machine); last chosen impedance is stored
22	TSACL	Time constant of anti-clipping of speaker amplifier
23	GSA	Current input for setting the gain of the speaker amplifier, adjustment characteristic is logarithmical, or $RGSA > 2 M\Omega$ , the speaker amplifier is switched off
24	SA I	Speaker amplifier input (for loudspeaker, tone ringer and hands-free use)
25	MUTX	Three-state input of transmit mute: 1. Speech condition; inputs MIC1/MIC2 active 2. DTMF condition; input DTMF active. A part of the input signal is passed to the receiving amplifier as a confidence signal during dialing 3. Input DTMF used for answering machine and hands-free use; receive branch not affected
26	ATAFS	Attenuation of acoustical feedback suppression, maximum attenuation of AFS circuit is set by a resistor at this pin, without the resistor, AFS is switched off
27	INLDT	Input of transmit level detector
28	INLDR	Input of receive level detector
29	TLDT	Time constant of transmit level detector

**Table 2-1.** Pin Description (Continued)

Pin	Symbol	Function
30	TLDR	Time constant of receive level detector
31	AGA	Automatic gain adjustment with line current, a resistor connected from this pin to GND sets the starting point, maximum gain change: 6 dB.
32	IREF	Internal reference current generation; RREF = 62 kΩ, IREF = 20 μA
33	STO	Sidetone reduction output Output resistance approximate: 300Ω, Maximum load impedance: 10 kΩ
34	VM	Reference node for microphone-earphone and loudspeaker amplifier, supply for electret microphone (IM ≤ 700 mA)
35	MUTR	Three-state mute input 1. Normal operation 2. Mute for ear piece 3. Mute for RECIN signal Condition of earpiece mute is stored
36	RECO2	Inverting output of receiving amplifier
37	STIS	Input for sidetone network (short loop) or for answering machine
38	STIL	Input for sidetone network (long loop)
39	RAC	Input of receiving amplifier for AC coupling in feedback path
40	RECO1	Output of receiving amplifier
41	GR	A resistor connected from this pin to GND sets the receiving amplification of the circuit; amplifier RA1 can be muted by applying VMP to GR
42	TTXA	Time constant of anti-clipping in transmit path
43	RECIN	Input of receiving path; input impedance is typically 80 kΩ
44	TXIN	Input of intermediate transmit stage, input resistance is typically 20 kΩ

Note: Filters against electromagnetic interference (EMI) are located at following pins: MIC1, MIC2, RECIN, TXIN, STIS, STIL and RAC.

### 3. DC Line Interface and Supply-voltage Generation

The DC line interface consists of an electronic inductance and a dual-port output stage which charges the capacitors at  $V_{MPS}$  and  $V_B$ . The value of the equivalent inductance is given by:

$$L = R_{SENSE} \times C_{IND} \times ((R_{DC} \times R_{30}) / (R_{DC} + R_{30}))$$

In order to improve the supply during worst-case operating conditions, two PNP current sources -  $I_{BOPT}$  and  $I_{MPSOPT}$  - hand an extra amount of current to the supply voltages when the NPNs in parallel are unable to conduct current.

A flowchart for the control of the current sources ([Figure 3-2](#)) shows how a priority for supply VMPS is achieved.

Figure 3-1. DC Line Interface with Electronic Inductance and Generation of a Regulated and an Unregulated Supply

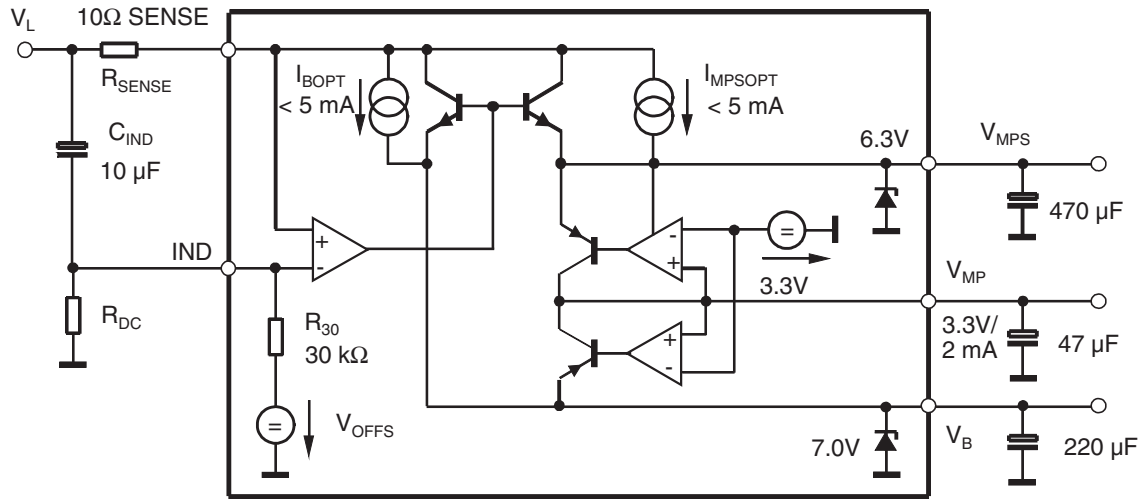
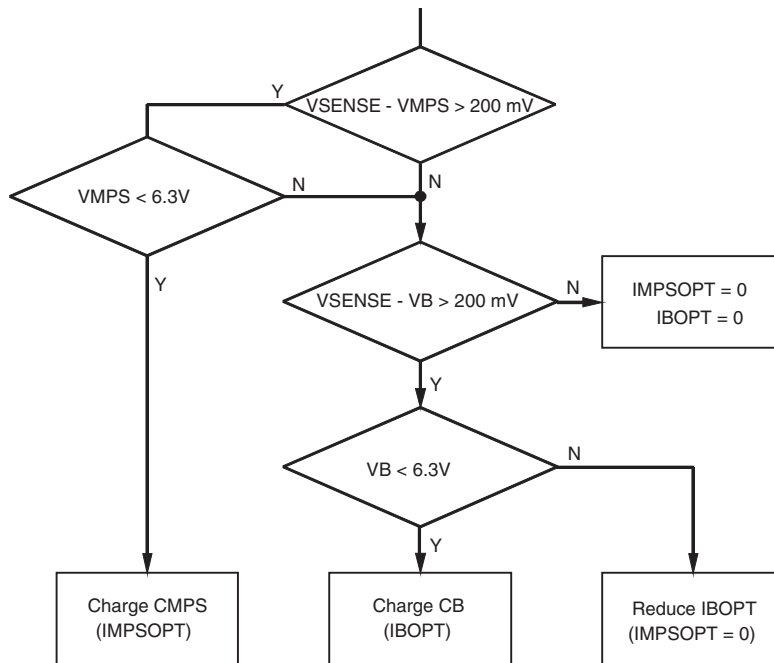
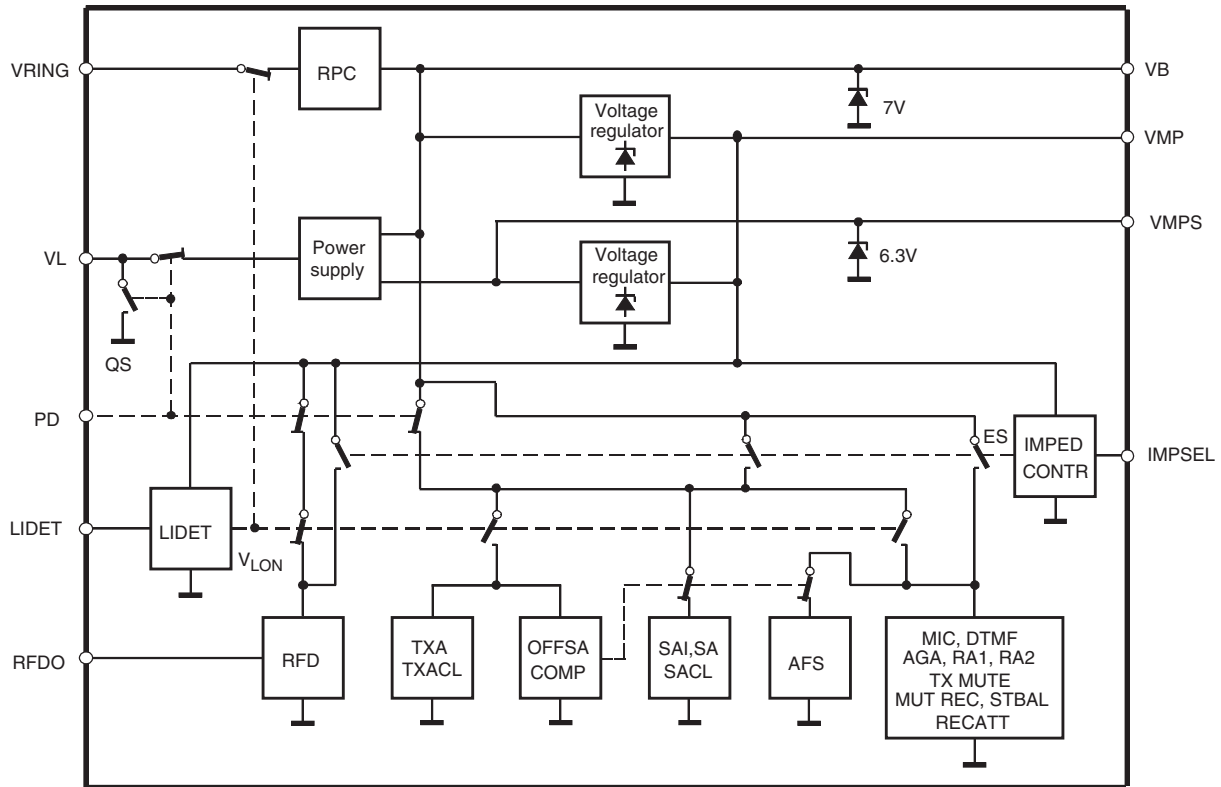


Figure 3-2. Supply Capacitors CMPS and CB Are Charged with Priority on CMPS



**Figure 3-3.** Supply of Functional Blocks Controlled by Input Voltages  $V_L$ ,  $V_B$ ,  $V_{RING}$  and by Logic Inputs PD and IMPSEL



The U4090B-P contains two identical series regulators which provide a supply voltage  $V_{MP}$  of 3.3V suitable for a microprocessor. In speech mode, both regulators are active because  $V_{MPS}$  and  $V_B$  are charged simultaneously by the DC-line interface. Output current is 4 mA. The capacitor at  $V_{MPS}$  is used to provide the microcomputer with sufficient power during long-line interruptions. Thus, long flash pulses can be bridged or an LCD display can be turned on for more than 2 seconds after going on hook. When the system is in ringing mode,  $V_B$  is charged by the on-chip ringing power converter. In this mode only one regulator is used to supply  $V_{MP}$  with a maximum of 2 mA.

### 3.1 Supply Structure of the Chip

A major benefit of the chip is that it uses a very flexible supply structure which allows simple realization of numerous applications such as:

- Group listening phone
- Hands-free phone
- Ringing with the built in speaker amplifier
- Answering machine with external supply

The special supply topology for the various functional blocks is illustrated in [Figure 3-3](#).



There are four major supply states:

1. **Speech condition:** In speech condition the system is supplied by the line current. If the LIDET-block detects a line voltage above the fixed threshold (1.9 V), the internal signal VLON is activated, thus switching off RFD and RPC and switching on all other blocks of the chip. At line voltages below 1.9V, the switches remain in their quiescent state as shown in [Figure 3-4 on page 10](#). OFFSACOMP disables the group listening feature (SAI, SA, SACL, AFS) below line currents of approximately 10 mA.
2. **Power down (pulse dialing):** When the chip is in power-down mode (PD = high), e.g., during pulse dialing, the internal switch QS shorts the line and all amplifiers are switched off. In this condition, LIDET, voltage regulators and IMPED CONTR are the only active blocks.
3. **Ringling:** During ringling, the supply for the system is fed into  $V_B$  via the ringling power converter (RPC). The only functional amplifiers are in the speaker amplifier section (SAI, SA, SACL).
4. **External supply:** In an answering machine, the chip is powered by an external supply via pin  $V_B$ . This application allows the possibility to activate all amplifiers (except the transmit line interface TXA). Selecting IMPSEL = high impedance activates all switches at the ES line.

## 3.2 Acoustic Feedback Suppression

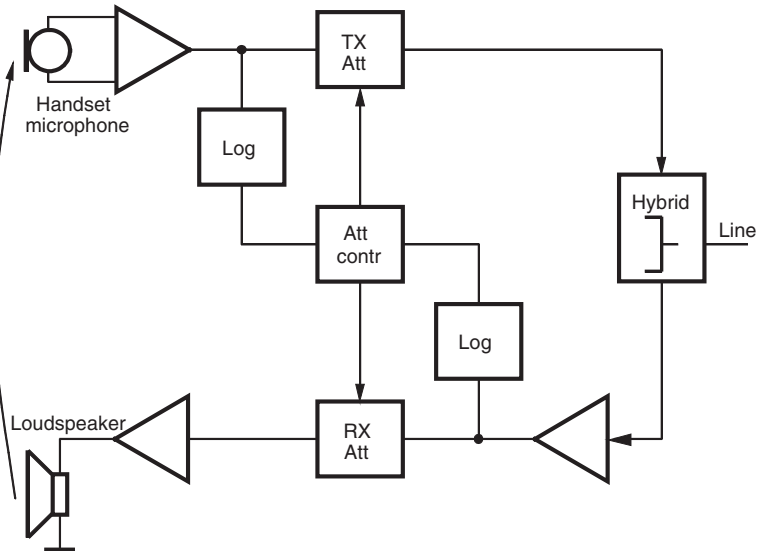
Acoustical feedback from the loudspeaker to the handset microphone may cause instability in the system. The U4090B-P offers a very efficient feedback suppression circuit, which uses a modified voice switch topology. [Figure 3-4 on page 10](#) shows the basic system configuration.

Two attenuators (TX ATT and RX ATT) reduce the critical loop gain by introducing an externally adjustable amount of loss either in the transmit or in the receive path. The sliding control in block ATT CONTR determines, whether the TX or the RX signal has to be attenuated. The overall loop gain remains constant under all operating conditions.

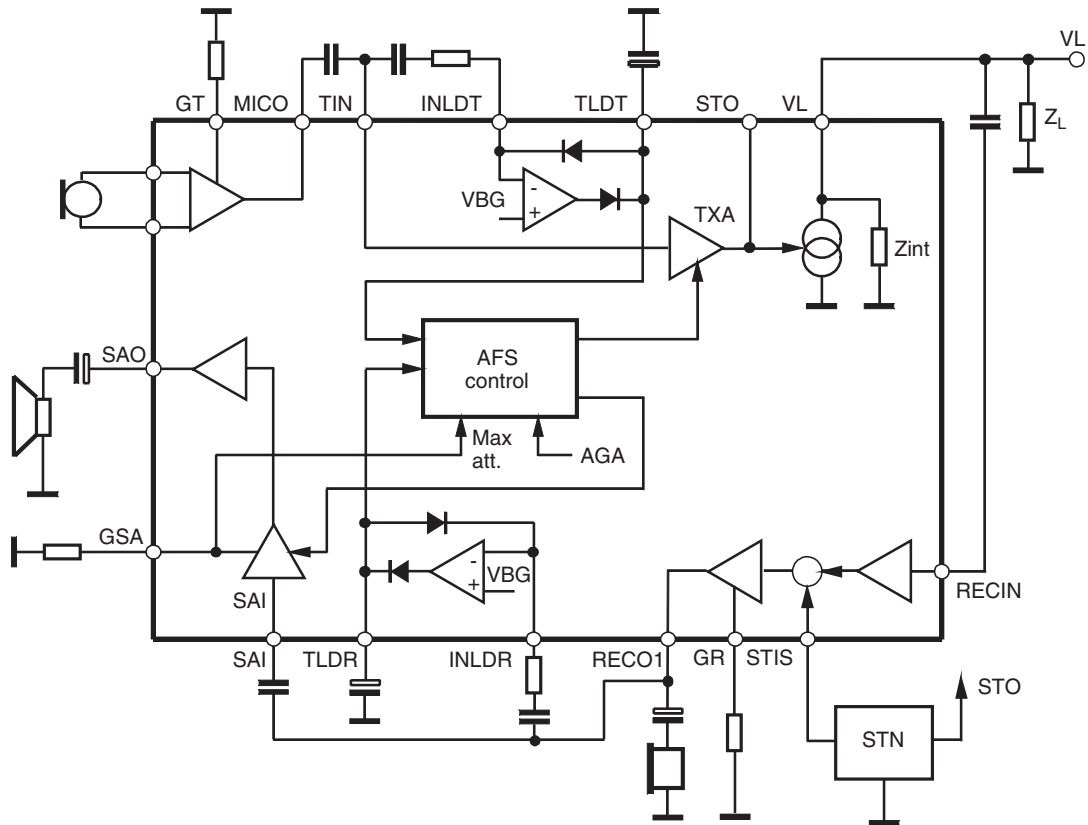
Selection of the active channel is made by comparison of the logarithmically compressed TX- and RX- envelope curve.

The system configuration for group listening, which is realized in the U4090B-P, is illustrated in [Figure 3-6 on page 11](#). TXA and SAI represent the two attenuators, the logarithmic envelope detectors are shown in a simplified way (operational amplifiers with two diodes).

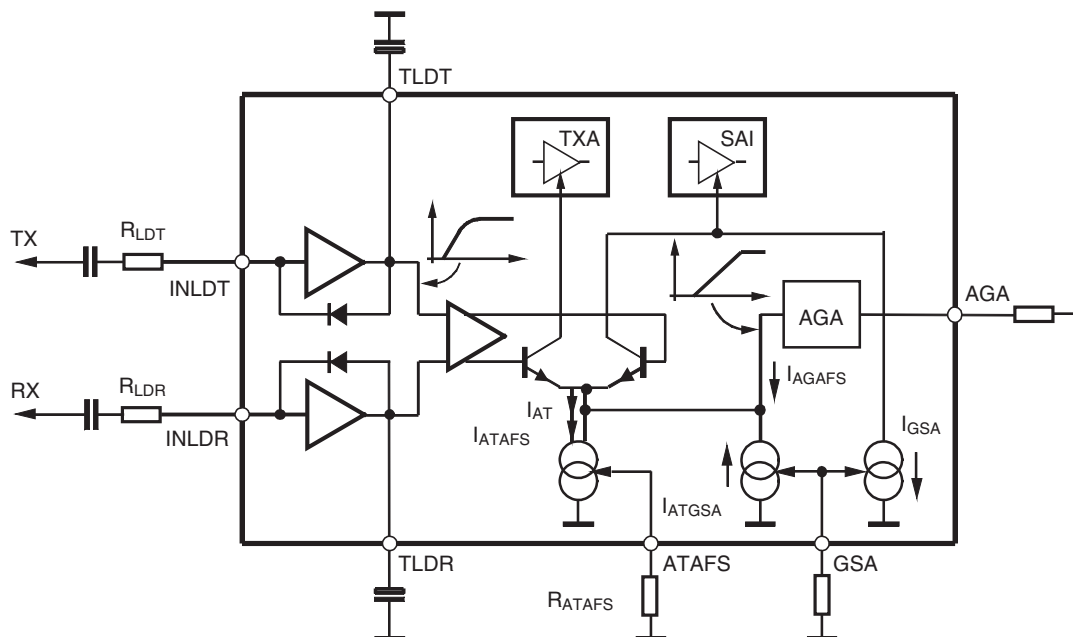
**Figure 3-4.** Basic Voice Switch System



**Figure 3-5.** Integration of the Acoustic Feedback Suppression Circuit into the Speech Circuit Environment



**Figure 3-6.** Acoustic Feedback Suppression by Alternative Control of Transmit and Speaker Amplifier Gain



A detailed diagram of the AFS (acoustic feedback suppression) is given in [Figure 3-6](#). Receive and transmit signals are first processed by logarithmic rectifiers in order to produce the envelopes of the speech at TLDT and RLDT. After amplification, a decision is made by the differential pair which direction should be transmitted.

The attenuation of the controlled amplifiers TXA and SAI is determined by the emitter current IAT which consists of three parts:

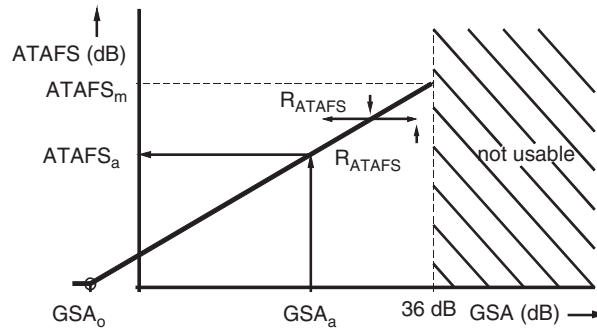
- $I_{ATAS}$  sets maximum attenuation
- $I_{ATGSA}$  decreases the attenuation when speaker amplifier gain is reduced
- $I_{AGAFS}$  decreases the attenuation according to the loop gain reduction caused by the AGA function

$$I_{AT} = I_{ATAFS} - I_{ATGSA} - I_{AGAFS}$$

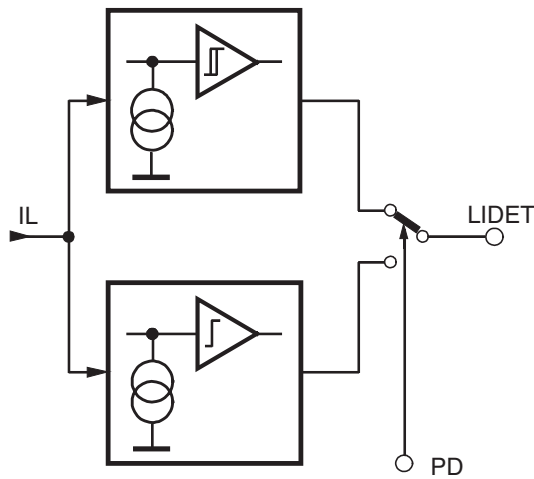
$$\Delta G = I_{AT} \times 0.67 \text{ dB}/\mu\text{A}$$

[Figure 3-7 on page 12](#) illustrates the principle relationship between speaker amplifier gain (GSA) and attenuation of AFS (ATAFS). Both parameters can be adjusted independently, but the internal coupling between them has to be considered. The maximum usable value of GSA is 36 dB. The shape of the characteristic is moved in the x-direction by adjusting resistor RATAFS, thus changing  $ATAFS_m$ . The actual value of attenuation ( $ATAFS_a$ ), however, can be determined by reading the value which belongs to the actual gain  $GSA_a$ . If the speaker amplifier gain is reduced, the attenuation of AFS is automatically reduced by the same amount in order to achieve a constant loop gain. Zero attenuation is set for speaker gains  $GSA \leq GSA0 = 36 \text{ dB} - ATAFS_m$ .

**Figure 3-7.** Reducing Speaker Amplifier Gain Results in an Equal Reduction of AFS Attenuation



**Figure 3-8.** Line Detection with Two Comparators for Speech Mode and Pulse Dialing

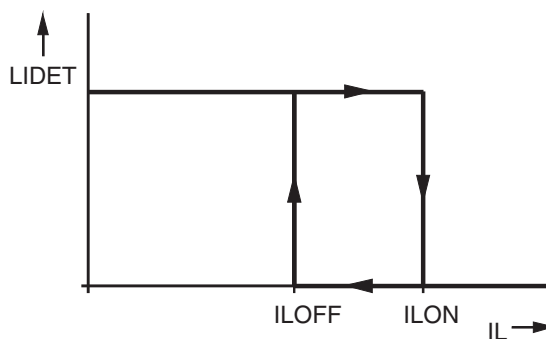


### 3.3 Line Detection (LIDET)

The line current supervision is active under all operating conditions of the U4090B-P. In speech mode (PD = inactive), the line-current comparator uses the same thresholds as the comparator for switching off the entire speaker amplifier. The basic behavior is illustrated in [Figure 3-9 on page 13](#). Actual values of ILON/ILOFF vary slightly with the adjustment of the DC characteristics and the selection of the internal line impedance.

When Power Down is activated (during pulse dialing), the entire line current flows through the short-circuiting transistor QS (see [Figure 3-3 on page 8](#)). As long as IL is above typically 1.6 mA, output LIDET is low. This comparator does not use hysteresis.

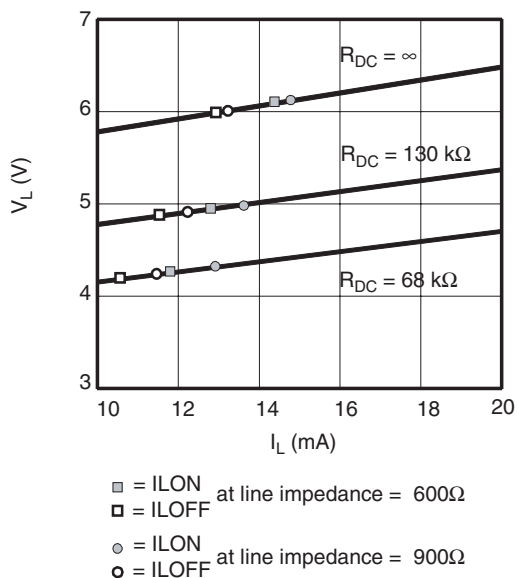
Figure 3-9. Line Detection in Speech Mode with Hysteresis



### 3.4 Ringing Power Converter (RPC)

The RPC transforms the input power at VRING (high voltage/low current) into an equivalent output power at  $V_B$  (low voltage/high current) which is capable of driving the low-ohmic loudspeaker. Input impedance at VRING is fixed at 5 k $\Omega$  and the efficiency of the step-down converter is approximate 65%.

Figure 3-10. Comparator Thresholds Depending on DC Mask and Line Impedance



### 3.5 Ringing Frequency Detector (RFD)

The U4090B-P offers an output signal for the microcontroller, which is a digital representation of the double ringing frequency. It is generated by a current comparator with hysteresis. The input voltage  $V_{RING}$  is transformed into a current via RTHA. The thresholds are 8  $\mu\text{A}$  and 24  $\mu\text{A}$ . RFDO and  $V_{RING}$  are in phase. A second comparator with hysteresis is used to enable the output RFDO as long as the supply voltage for the microprocessor VMP is above 2.0V.

## 4. Absolute Maximum Ratings

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameters	Symbol	Value	Unit
Line current	$I_L$	140	mA
DC line voltage	$V_L$	12	V
Maximum input current, pin 17	$I_{RING}$	15	mA
Junction temperature	$T_j$	125	°C
Ambient temperature	$T_{amb}$	-25 to +75	°C
Storage temperature	$T_{stg}$	-55 to +150	°C
Total power dissipation, $T_{amb} = 60^\circ\text{C}$	$P_{tot}$	0.9	W

## 5. Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient SSO44	$R_{thJA}$	70	K/W

## 6. Electrical Characteristics

$f = 1 \text{ kHz}$ ,  $0 \text{ dBm} = 775 \text{ mV}_{rms}$ ,  $I_M = 0.3 \text{ mA}$ ,  $I_{MP} = 2 \text{ mA}$ ,  $R_{DC} = 130 \text{ k}\Omega$ ,  $T_{amb} = 25^\circ\text{C}$ ,  $R_{GSA} = 560 \text{ k}\Omega$ ,  $Z_{ear} = 68 \text{ nF} + 100\Omega$ ,  $Z_M = 68 \text{ nF}$ , pin 31 open,  $V_{IMPSEL} = \text{GND}$ ,  $V_{MUTX} = \text{GND}$ ,  $V_{MUTR} = \text{GND}$ , unless otherwise specified.

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
<b>DC Characteristics</b>						
DC voltage drop over circuit	$I_L = 2 \text{ mA}$ $I_L = 14 \text{ mA}$ $I_L = 60 \text{ mA}$ $I_L = 100 \text{ mA}$	$V_L$	4.6 8.8	2.4 5.0 7.5 9.4	5.4 10.0	V
<b>Transmission Amplifier, <math>I_L = 14 \text{ mA}</math>, <math>V_{MIC} = 2 \text{ mV}</math>, <math>R_{GT} = 27 \text{ k}\Omega</math>, Unless Otherwise Specified</b>						
Range of transmit gain		$G_T$	40	45	50	dB
Transmitting amplification	$R_{GT} = 12 \text{ k}\Omega$ $R_{GT} = 27 \text{ k}\Omega$	$G_T$	47 39.8	48	49 41.8	dB
Frequency response	$I_L \geq 14 \text{ mA}$ $f = 300 \text{ to } 3400 \text{ Hz}$	$\Delta G_T$			$\pm 0.5$	dB
Gain change with current	Pin 31 open $I_L = 14 \text{ to } 100 \text{ mA}$	$\Delta G_T$			$\pm 0.5$	dB
Gain deviation	$T_{amb} = -10 \text{ to } +60^\circ\text{C}$	$\Delta G_T$			$\pm 0.5$	dB
CMRR of microphone amplifier		CMRR	60	80		dB
Input resistance of MIC amplifier	$R_{GT} = 12 \text{ k}\Omega$ $R_{GT} = 27 \text{ k}\Omega$	$R_i$	45	50 75	110	$\text{k}\Omega$
Distortion at line	$I_L > 14 \text{ mA}$ $V_L = 700 \text{ mV}_{rms}$	$d_t$			2	%
Maximum output voltage	$I_L > 19 \text{ mA}$ , $d < 5\%$ $V_{MIC} = 25 \text{ mV}$ $CTXA = 1 \mu\text{F}$	$V_{Lmax}$	1.8	3	4.2	dBm
	IMPSEL = open $R_{GT} = 12 \text{ k}\Omega$	$V_{MIComax}$		-5.2		dBm

## 6. Electrical Characteristics (Continued)

f = 1 kHz, 0 dBm = 775 mV<sub>rms</sub>, I<sub>M</sub> = 0.3 mA, I<sub>MP</sub> = 2 mA, RDC = 130 kΩ, T<sub>amb</sub> = 25°C, RGSA = 560 kΩ, Z<sub>ear</sub> = 68 nF + 100Ω, Z<sub>M</sub> = 68 nF, pin 31 open, V<sub>IMPSEL</sub> = GND, V<sub>MUTX</sub> = GND, V<sub>MUTR</sub> = GND, unless otherwise specified.

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
Noise at line psophometrically weighted	I <sub>L</sub> > 14 mA G <sub>T</sub> = 48 dB	no		-80	-72	dBmp
Anti-clipping attack time release time	CTXA = 1 μF each 3 dB overdrive			0.5 9		ms
Gain at low operating current	I <sub>L</sub> = 10 mA I <sub>MP</sub> = 1 mA RDC = 68 kΩ V <sub>MIC</sub> = 1 mV I <sub>M</sub> = 300 μA	G <sub>T</sub>	40		42.5	dB
Distortion at low operating current	I <sub>L</sub> = 10 mA I <sub>M</sub> = 300 μA I <sub>MP</sub> = 1 mA RDC = 68 kΩ V <sub>MIC</sub> = 10 mV	d <sub>t</sub>			5	%
Line loss compensation	I <sub>L</sub> = 100 mA R <sub>AGA</sub> = 20 kΩ	ΔG <sub>TI</sub>	-6.4	-5.8	-5.2	dB
Mute suppression a) MIC muted (microphone preamplifier) b) TXA muted (second stage)	I <sub>L</sub> ≥ 14 mA MUTX = open  IMPSEL = open	G <sub>TM</sub>  G <sub>TTX</sub>	60  60	80		dB  dB
<b>Receiving Amplifier, I<sub>L</sub> = 14 mA, R<sub>GR</sub> = 62 kΩ, Unless Otherwise Specified, V<sub>GEN</sub> = 300 mV</b>						
Adjustment range of receiving gain	I <sub>L</sub> ≥ 14 mA, single ended differential MUTR = GND	G <sub>R</sub>	-8 -2		+2 +8	dB
Receiving amplification	R <sub>GR</sub> = 62 kΩ differential R <sub>GR</sub> = 22 kΩ differential	G <sub>R</sub>	-1.75	-1 7.5	-0.25	dB
Amplification of DTMF signal from DTMF IN to RECO 1, 2	I <sub>L</sub> ≥ 14 mA V <sub>MUTX</sub> = V <sub>MP</sub>	G <sub>RM</sub>	7	10	13	dB
Frequency response	I <sub>L</sub> > 14 mA, f = 300 to 3400 Hz	ΔG <sub>RF</sub>			±0.5	dB
Gain change with current	I <sub>L</sub> = 14 to 100 mA	ΔG <sub>R</sub>			±0.5	dB
Gain deviation	T <sub>amb</sub> = -10 to +60°C	ΔG <sub>R</sub>			±0.5	dB
Ear-protection differential	I <sub>L</sub> ≥ 14 mA, V <sub>GEN</sub> = 11 V <sub>rms</sub>	EP			2.2	V <sub>rms</sub>
MUTE suppression a) RECATT b) RA2 c) DTMF operation	I <sub>L</sub> ≥ 14 mA MUTR = open V <sub>MUTR</sub> = V <sub>MP</sub> V <sub>MUTX</sub> = V <sub>MP</sub>	ΔG <sub>R</sub>	60			dB
Output voltage d ±2% differential	I <sub>L</sub> = 14 mA, Z <sub>ear</sub> = 68 nF + 100Ω		0.775			V <sub>rms</sub>
Maximum output current d ±2%	Z <sub>ear</sub> = 100Ω		4			mA (peak)
Receiving noise psophometrically weighted	Z <sub>ear</sub> = 68 nF + 100Ω I <sub>L</sub> ≥ 14 mA	ni		-80	-77	dBmp
Output resistance	Each output against GND	R <sub>o</sub>			10	Ω
Line loss compensation	R <sub>AGA</sub> = 20 kΩ, I <sub>L</sub> = 100 mA	ΔG <sub>RI</sub>	-7.0	-6.0	-5.0	dB

## 6. Electrical Characteristics (Continued)

$f = 1 \text{ kHz}$ ,  $0 \text{ dBm} = 775 \text{ mV}_{\text{rms}}$ ,  $I_M = 0.3 \text{ mA}$ ,  $I_{MP} = 2 \text{ mA}$ ,  $RDC = 130 \text{ k}\Omega$ ,  $T_{\text{amb}} = 25^\circ\text{C}$ ,  $R_{GSA} = 560 \text{ k}\Omega$ ,  $Z_{\text{ear}} = 68 \text{ nF} + 100\Omega$ ,  $Z_M = 68 \text{ nF}$ , pin 31 open,  $V_{\text{IMPSEL}} = \text{GND}$ ,  $V_{\text{MUTX}} = \text{GND}$ ,  $V_{\text{MUTR}} = \text{GND}$ , unless otherwise specified.

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
Gain at low operating current	$I_L = 10 \text{ mA}$ $I_{MP} = 1 \text{ mA}$ $I_M = 300 \mu\text{A}$ $V_{\text{GEN}} = 560 \text{ mV}$ $RDC = 68 \text{ k}\Omega$	$G_R$	-2	-1	0	dB
AC impedance	$V_{\text{IMPSEL}} = \text{GND}$ $V_{\text{IMPSEL}} = V_{MP}$	$Z_{\text{imp}}$ $Z_{\text{imp}}$	570 840	600 900	640 960	$\Omega$ $\Omega$
Distortion at low operating current	$I_L = 10 \text{ mA}$ $I_{MP} = 1 \text{ mA}$ $V_{\text{GEN}} = 560 \text{ mV}$ $RDC = 68 \text{ k}\Omega$	dR			5	%
<b>Speaker Amplifier</b>						
Minimum line current for operation	No AC signal	$I_{L\text{min}}$			15	mA
Input resistance	Pin 24		14		22	k $\Omega$
Gain from SAI to SAO	$V_{\text{SAI}} = 3 \text{ mV}$ $I_L = 15 \text{ mA}$ $R_{\text{GSA}} = 560 \text{ k}\Omega$ $R_{\text{GSA}} = 20 \text{ k}\Omega$	$G_{\text{SA}}$	35.5	36.5 -3	37.5	dB
Output power	Load resistance $R_L = 50\Omega$ , $d < 5\%$ $V_{\text{SAI}} = 20 \text{ mV}$ $I_L = 15 \text{ mA}$ $I_L = 20 \text{ mA}$	$P_{\text{SA}}$ $P_{\text{SA}}$	3	7 20		mW
Output noise (Input SAI open) psophometrically weighted	$I_L > 15 \text{ mA}$	$n_{\text{SA}}$			200	$\mu\text{V}_{\text{psoph}}$
Gain deviation	$I_L = 15 \text{ mA}$ , $T_{\text{amb}} = -10 \text{ to } +60^\circ\text{C}$	$\Delta G_{\text{SA}}$			$\pm 1$	dB
Mute suppression	$I_L = 15 \text{ mA}$ $V_L = 0 \text{ dBm}$ $V_{\text{SAI}} = 4 \text{ mV}$ Pin 23 open	$V_{\text{SAO}}$			-60	dBm
Gain change with current	$I_L = 15 \text{ to } 100 \text{ mA}$	$\Delta G_{\text{SA}}$			$\pm 1$	dB
Resistor for turning off speaker amplifier	$I_L = 15 \text{ to } 100 \text{ mA}$	$R_{\text{GSA}}$	0.8	1.3	2	M $\Omega$
Gain change with frequency	$I_L = 15 \text{ mA}$ , $f = 300 \text{ to } 3400 \text{ Hz}$	$\Delta G_{\text{SA}}$			$\pm 0.5$	dB
Attack time of anti-clipping	20 dB over drive	tr		5		ms
Release time of anti-clipping		tf		80		ms
<b>DTMF Amplifier Test Conditions: <math>I_{MP} = 2 \text{ mA}</math>, <math>I_M = 0.3 \text{ mA}</math>, <math>V_{\text{MUTX}} = V_{MP}</math></b>						
Adjustment range of DTMF gain	$I_L = 15 \text{ mA}$ mute active	$G_D$	40		50	dB
DTMF amplification	$I_L = 15 \text{ mA}$ $V_{\text{DTMF}} = 8 \text{ mV}$ Mute active: $\text{MUTX} = V_{MP}$	$G_D$	40.7	41.7	42.7	dB
Gain deviation	$I_L = 15 \text{ mA}$ , $T_{\text{amb}} = -10 \text{ to } +60^\circ\text{C}$	$G_D$			$\pm 0.5$	dB
Input resistance	$R_{\text{GT}} = 27 \text{ k}\Omega$ $R_{\text{GT}} = 15 \text{ k}\Omega$	$R_i$	60 26	180 70	300 130	k $\Omega$
Distortion of DTMF signal	$I_L \geq 15 \text{ mA}$ $V_L = 0 \text{ dBm}$	$d_D$			2	%



## 6. Electrical Characteristics (Continued)

$f = 1 \text{ kHz}$ ,  $0 \text{ dBm} = 775 \text{ mV}_{\text{rms}}$ ,  $I_M = 0.3 \text{ mA}$ ,  $I_{MP} = 2 \text{ mA}$ ,  $RDC = 130 \text{ k}\Omega$ ,  $T_{\text{amb}} = 25^\circ\text{C}$ ,  $RGSA = 560 \text{ k}\Omega$ ,  $Z_{\text{ear}} = 68 \text{ nF} + 100\Omega$ ,  $Z_M = 68 \text{ nF}$ , pin 31 open,  $V_{\text{IMPSEL}} = \text{GND}$ ,  $V_{\text{MUTX}} = \text{GND}$ ,  $V_{\text{MUTR}} = \text{GND}$ , unless otherwise specified.

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
Gain deviation with current	$I_L = 15 \text{ to } 100 \text{ mA}$	$\Delta G_D$			$\pm 0.5$	dB
<b>AFS Acoustic Feedback Suppression</b>						
Adjustment range of attenuation	$I_L \geq 15 \text{ mA}$		0		50	dB
Attenuation of transmit gain	$I_L \geq 15 \text{ mA}$ $I_{\text{INLDT}} = 0 \mu\text{A}$ $R_{\text{ATAFS}} = 30 \text{ k}\Omega$ $I_{\text{INLDR}} = 10 \mu\text{A}$	$\Delta G_T$		45		dB
Attenuation of speaker amplifier	$I_L \geq 15 \text{ mA}$ $I_{\text{INLDP}} = 0 \mu\text{A}$ $R_{\text{ATAFS}} = 30 \text{ k}\Omega$ $I_{\text{INLDR}} = 10 \mu\text{A}$	$\Delta G_{SA}$		50		dB
AFS disable	$I_L \geq 15 \text{ mA}$	$V_{\text{ATAFS}}$	1.5			V
<b>Supply Voltages, <math>V_{\text{MIC}} = 25 \text{ mV}</math>, <math>T_{\text{amb}} = -10 \text{ to } +60^\circ\text{C}</math></b>						
$V_{MP}$	$I_L = 14 \text{ mA}$ $RDC = 68 \text{ k}\Omega$ $I_{MP} = 2 \text{ mA}$	$V_{MP}$	3.1	3.3	3.5	V
$V_{MPS}$	$I_L = 100 \text{ mA}$ $RDC = \text{infinite}$ $I_{MP} = 0 \text{ mA}$	$V_{MPS}$			6.7	V
$V_M$	$I_L \geq 14 \text{ mA}$ $I_M = 700 \mu\text{A}$ $RDC = 130 \text{ k}\Omega$	$V_M$	1.3		3.3	V
$V_B$	$I_B = 20 \text{ mA}$ $I_L = 0 \text{ mA}$	$V_B$		7	7.6	V
<b>Ring Power Converter, <math>IMP = 1 \text{ mA}</math>, <math>IM = 0</math></b>						
Maximum output power	$V_{\text{RING}} = 20.6\text{V}$	$P_{SA}$		20		mW
Threshold of ring frequency detector	RFDO: low to high $V_{\text{HYST}} = V_{\text{RINGON}} - V_{\text{RINGOFF}}$	$V_{\text{RINGON}}$ $V_{\text{HYST}}$		17.5 11.0		V
Input impedance	$V_{\text{RING}} = 30\text{V}$	$R_{\text{RING}}$	4	5	6	k $\Omega$
Input impedance in speech mode	$f = 300 \text{ Hz to } 3400 \text{ Hz}$ $I_L > 15 \text{ mA}$ $V_{\text{RING}} = 20\text{V} + 1.5\text{V}_{\text{rms}}$	$R_{\text{RINGSP}}$	150			k $\Omega$
Logic level of frequency detector	$V_{\text{RING}} = 0\text{V}$ $V_B = 4\text{V}$ $V_{\text{RING}} = 25\text{V}$	$V_{\text{RFDO}}$		0 $V_{MP}$		V
Ring detector enable	$V_{\text{RING}} = 25\text{V}$ , RFDO high	$V_{\text{MPON}}$	1.8	2.0	2.2	V
Zener diode voltage	$I_{\text{RING}} = 25 \text{ mA}$	$V_{\text{RINGmax}}$	30.8		33.3	V
<b>MUTR Input</b>						
MUTR input current	$V_{\text{MUTR}} = \text{GND}$ $I_L > 14 \text{ mA}$ $V_{\text{MUTR}} = V_{MP}$	$I_{\text{MUTE}}$		-20 +10	-30	$\mu\text{A}$
MUTR input voltage	Mute low; $I_L > 14 \text{ mA}$	$V_{\text{MUTE}}$			0.3	V
	Mute high; $I_L > 14 \text{ mA}$	$V_{\text{MUTE}}$	$V_{MP} - 0.3\text{V}$			V

## 6. Electrical Characteristics (Continued)

$f = 1 \text{ kHz}$ ,  $0 \text{ dBm} = 775 \text{ mV}_{\text{rms}}$ ,  $I_M = 0.3 \text{ mA}$ ,  $I_{MP} = 2 \text{ mA}$ ,  $RDC = 130 \text{ k}\Omega$ ,  $T_{\text{amb}} = 25^\circ\text{C}$ ,  $RGSA = 560 \text{ k}\Omega$ ,  $Z_{\text{ear}} = 68 \text{ nF} + 100\Omega$ ,  $Z_M = 68 \text{ nF}$ , pin 31 open,  $V_{\text{IMPSEL}} = \text{GND}$ ,  $V_{\text{MUTX}} = \text{GND}$ ,  $V_{\text{MUTR}} = \text{GND}$ , unless otherwise specified.

Parameters	Test Conditions	Symbol	Min.	Typ.	Max.	Unit
<b>PD Input</b>						
PD input current	PD active, $I_L > 14 \text{ mA}$ $V_{PD} = V_{MP}$	$I_{pd}$		9		$\mu\text{A}$
Input voltage	PD = active PD = inactive	$V_{pd}$ $V_{pd}$	2		0.3	V
Voltage drop at $V_L$	$I_L = 14 \text{ mA}$ , PD = active $I_L = 100 \text{ mA}$ , PD = active	$V_L$		1.5 1.9		V
<b>Input Characteristics of IMPSEL</b>						
Input current	$I_L \geq 14 \text{ mA}$ $V_{\text{IMPSEL}} = V_{MP}$ $V_{\text{IMPSEL}} = \text{GND}$	$I_{\text{IMPSEL}}$ $I_{\text{IMPSEL}}$		18 -18		$\mu\text{A}$ $\mu\text{A}$
Input voltage	Input high	$V_{\text{IMPSEL}}$	$V_{MP} - 0.3\text{V}$			V
	Input low	$V_{\text{IMPSEL}}$			0.3	V
<b>MUTX Input</b>						
Input current	$V_{\text{MUTX}} = V_{MP}$ $V_{\text{MUTX}} = \text{GND}$	$I_{\text{MUTX}}$ $I_{\text{MUTX}}$		20 -20	30 -30	$\mu\text{A}$ $\mu\text{A}$
Input voltage	Input high	$V_{\text{MUTX}}$	$V_{MP} - 0.3\text{V}$			V
	Input low	$V_{\text{MUTX}}$			0.3	V
<b>Line Detection</b>						
Line current for LIDET active	PD = inactive	ILON		12.6		mA
Line current for LIDET inactive	PD = inactive	ILOFF		11.0		mA
Current threshold during power down	$V_B = 5\text{V}$ , PD = active	ILONPD	0.8	1.6	2.4	mA

## 7. U4090B-P Control

**Table 7-1.** Selection of TX Mute and Line Impedance

Logic Level	IMPSEL	MODE
0	Line impedance = 600Ω TXA = on ES = off	Speech
0 to Z	Line impedance = 600Ω TXA = off ES = on	Transmit-mute
1 to Z	Line impedance = 900Ω TXA = off ES = on	Transmit-mute
1	Line impedance = 900Ω TXA = on ES = off	Speech

**Table 7-2.** Selection of Earpiece Mute and Answering Machine Mode

Logic Level	MUTR	MODE
0	RA2 = on RECATT = on STIS + STIL = on	Speech
0 to Z	RA2 = on RECATT = off STIS = on, STIL = off	For answering machine
1 to Z	RA2 = off RECATT = off STIS = on, STIL = off AGA off for STIS	For answering machine
1	RA2 = off RECATT = on STIS + STIL = on	Speech + earpiece mute

**Table 7-3.** Selection of Transmit Mute

Logic Level	MUTX	MODE
0	MIC 1/2 transmit enabled receive enable AFS = on AGA = on TXACL = on	Speech
Z	DTMF transmit enabled receive enable AFS = on AGA = on TXACL = on	For answering machine
1	DTMF transmit enabled DTMF to receive enable AFS = off AGA = off TXACL = off	DTMF dialling

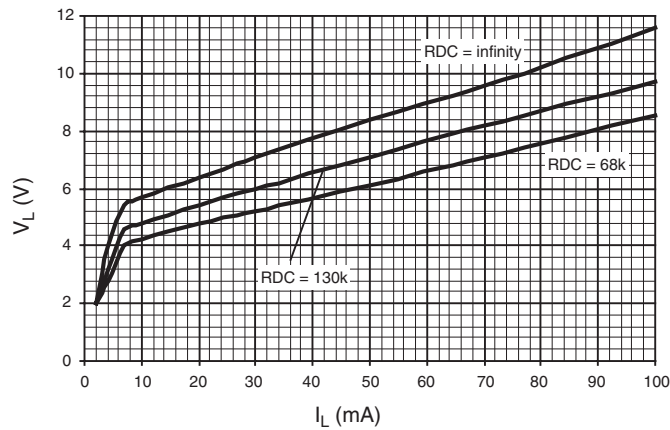
**Table 7-4.** Specification of Logic Levels

Logic Level
0 = < (0.3V)
Z = > (1V) < (VMP - 1V) or (open input)
1 = > (VMP - 0.3V)

## 8. Explanation of Abbreviations

RECATT = Receive attenuation  
 STIS, STIL = Inputs of sidetone balancing amplifiers  
 ES = External supply  
 AFS = Acoustic feedback suppression control  
 AGA = Automatic gain adjustment  
 RA2 = Inverting receive amplifier  
 TXACL = Transmit anti-clipping control

**Figure 8-1.** Typical DC Characteristic



**Figure 8-2.** Typical Adjustment Range of Transmit Gain

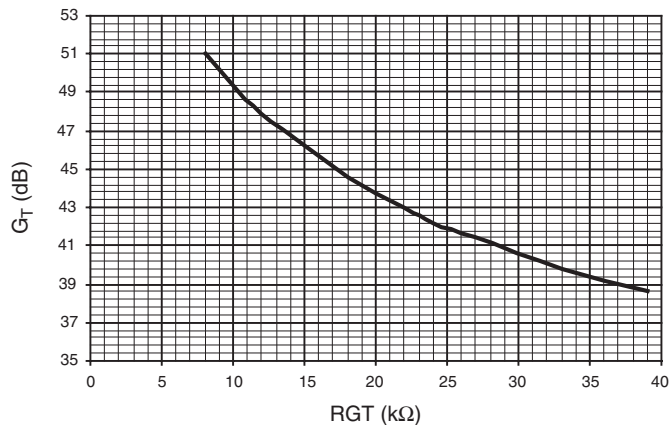


Figure 8-3. Typical Adjustment Range of Receive Gain (Differential Output)

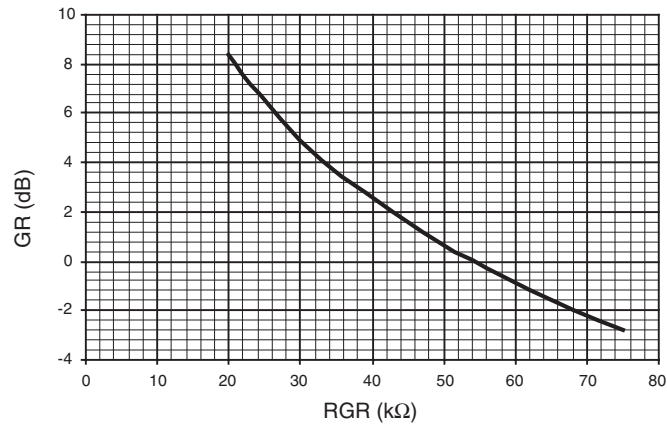


Figure 8-4. Typical AGA Characteristic

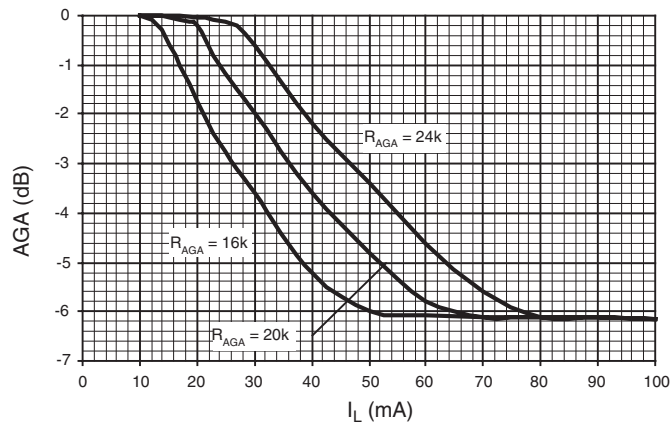
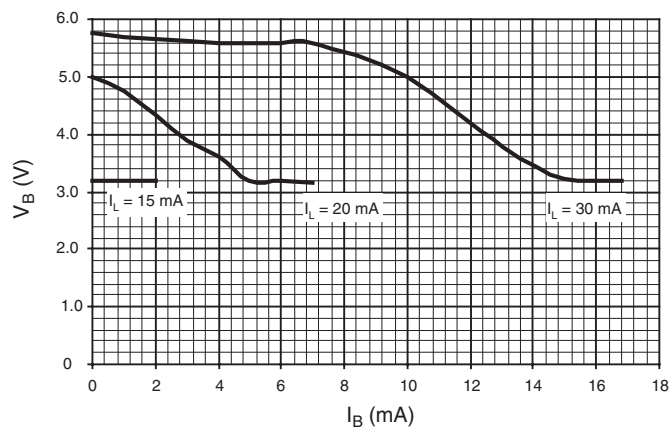
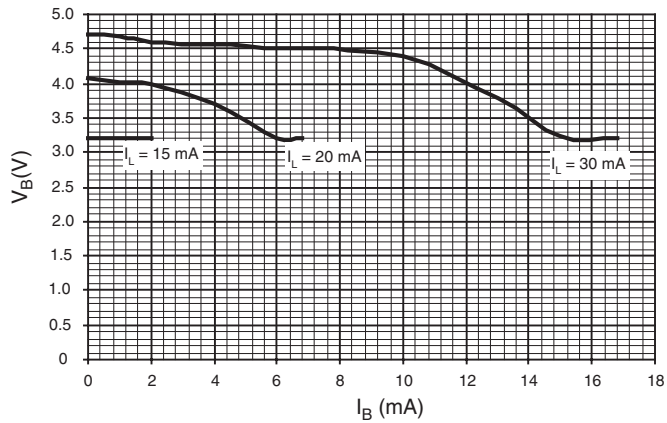


Figure 8-5. Typical Load Characteristic of V\_B for a Maximum (RDC = Infinity) DC-characteristic and 3-mW Loudspeaker Output



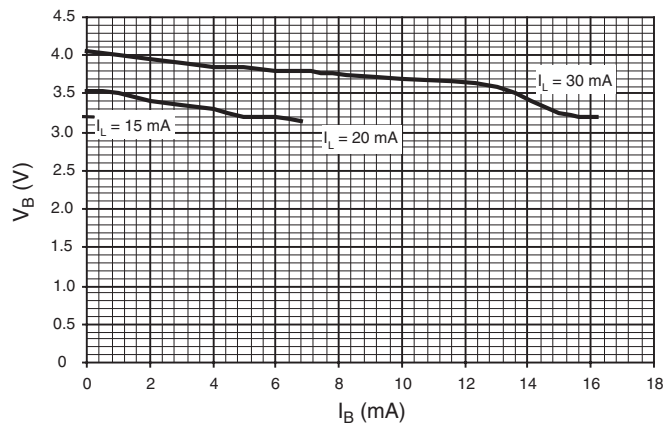
RDC = Infinity; V<sub>I</sub> = 200 mV/1 kHz; PSAO = 3 mW;  
 IMP = 2 mA; IM = 300 μA; RGSA = 560k

**Figure 8-6.** Typical Load Characteristic of  $V_B$  for a Medium DC-characteristic (RDC = 130 k $\Omega$ ) and 3-mW Loudspeaker Output



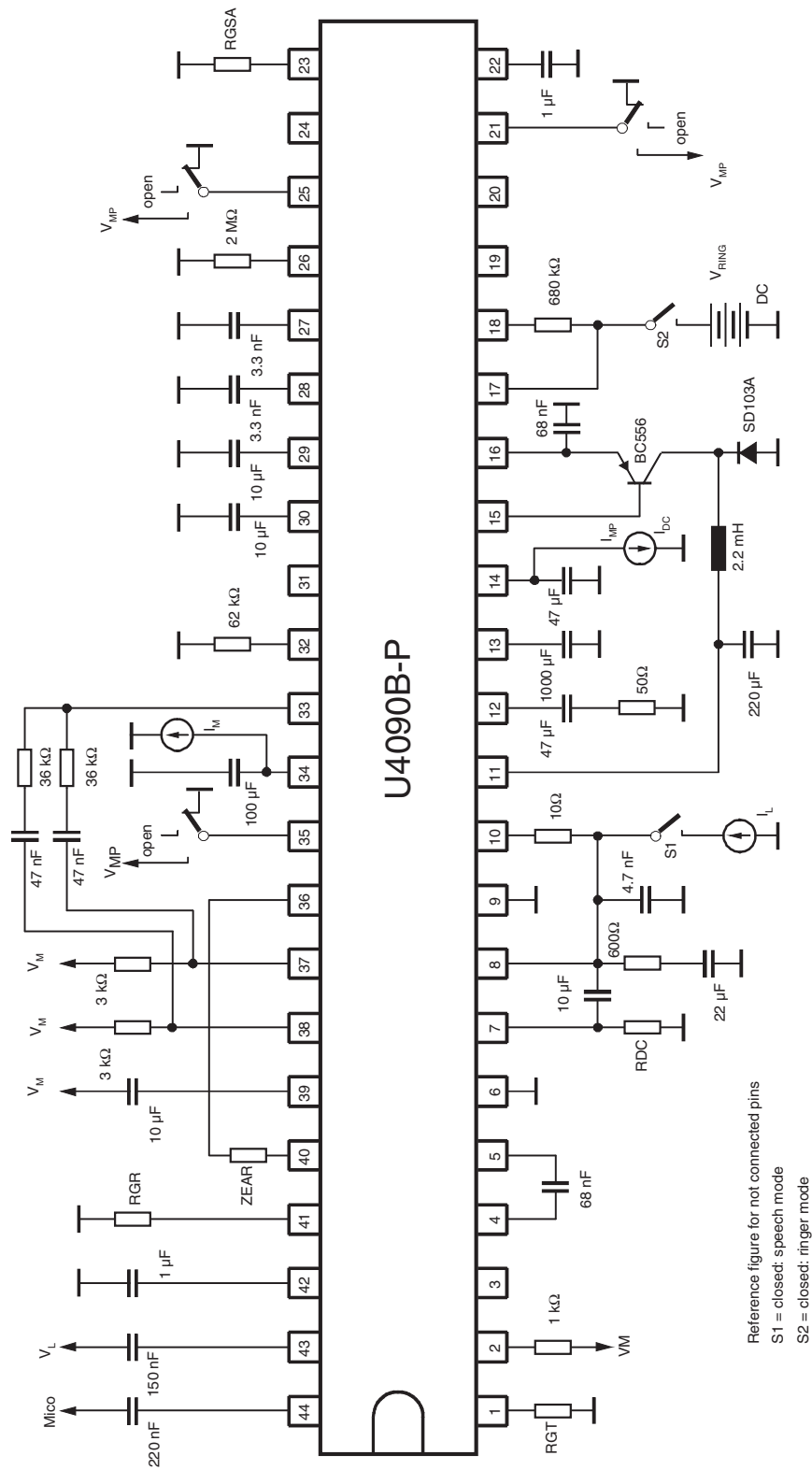
RDC = 130 k; VI = 200 mV/1 kHz; PSAO = 3 mW;  
IMP = 2 mA; IM = 300  $\mu$ A; RGSA = 560k

**Figure 8-7.** Typical Load Characteristic of  $V_B$  for a Minimum DC-characteristic (RDC = 68 k $\Omega$ ) and 3-mW Loudspeaker Output



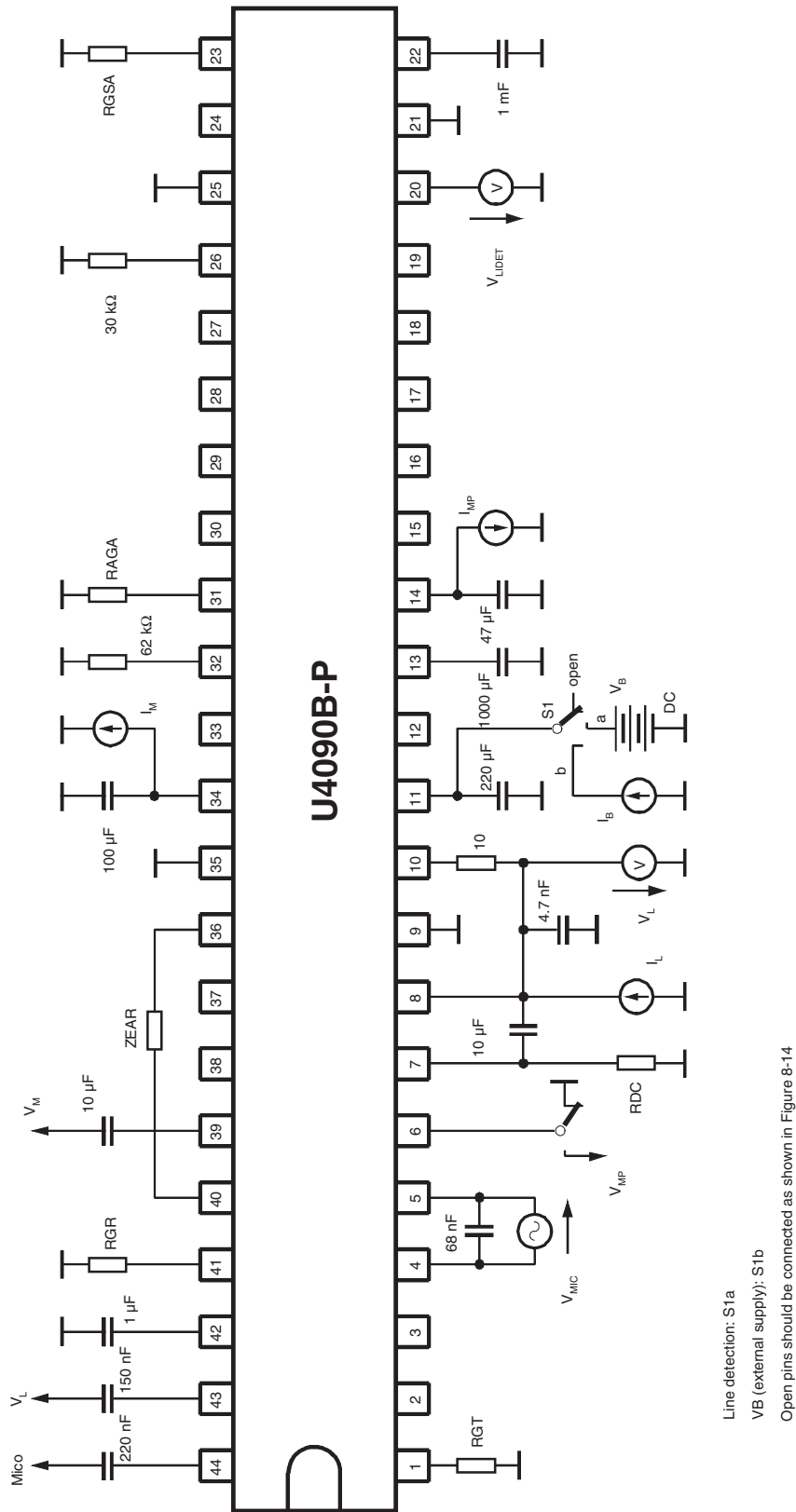
RDC = 68 k; VI = 200 mV; PSAO = 3 mW; IMP = 2 mA;  
IM = 300  $\mu$ A; RGSA = 560k

**Figure 8-8.** Basic Test Circuit



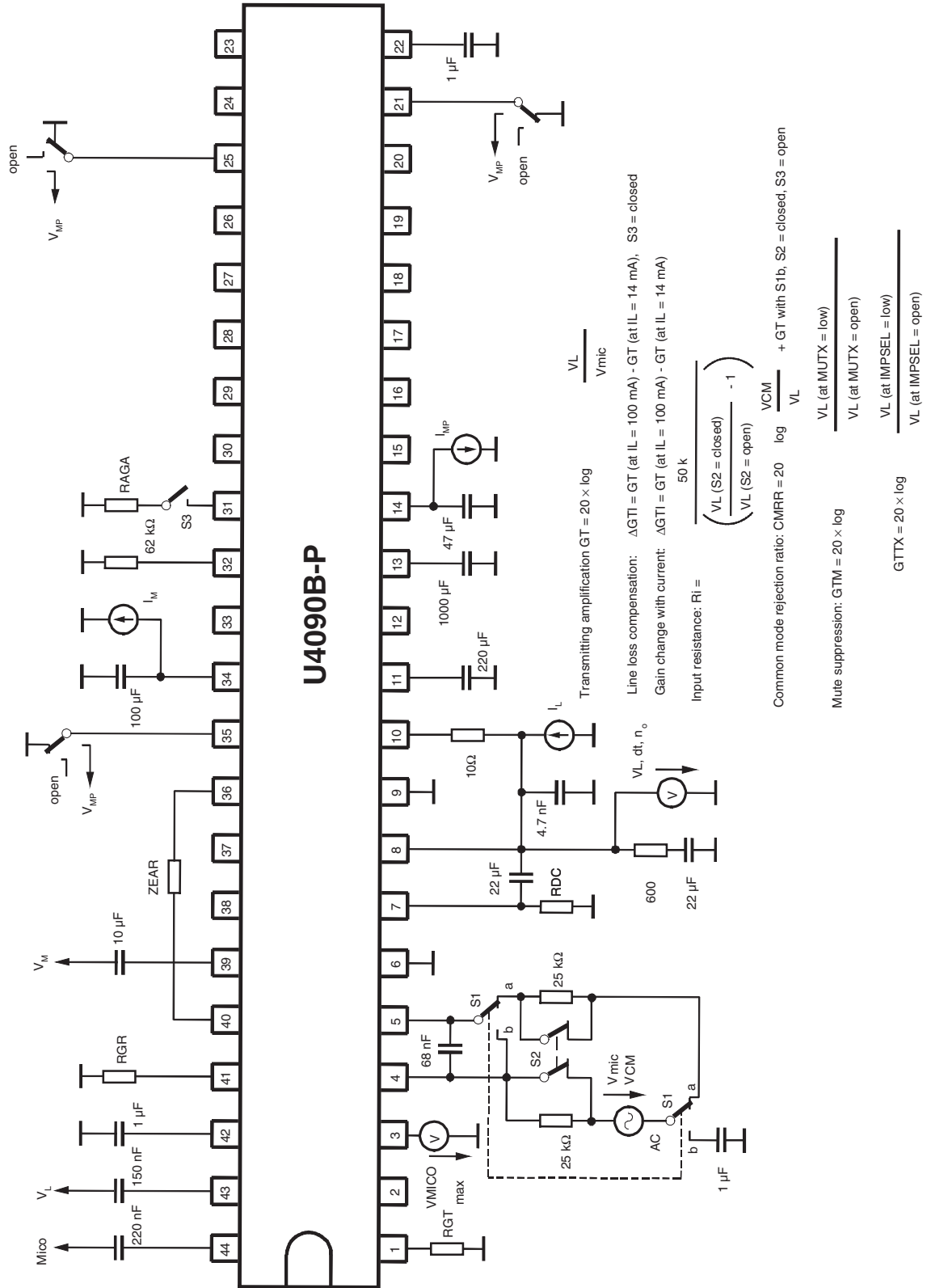
Reference figure for not connected pins  
 S1 = closed: speech mode  
 S2 = closed: ringer mode

**Figure 8-9.** Test Circuit for DC Characteristics and Line Detection

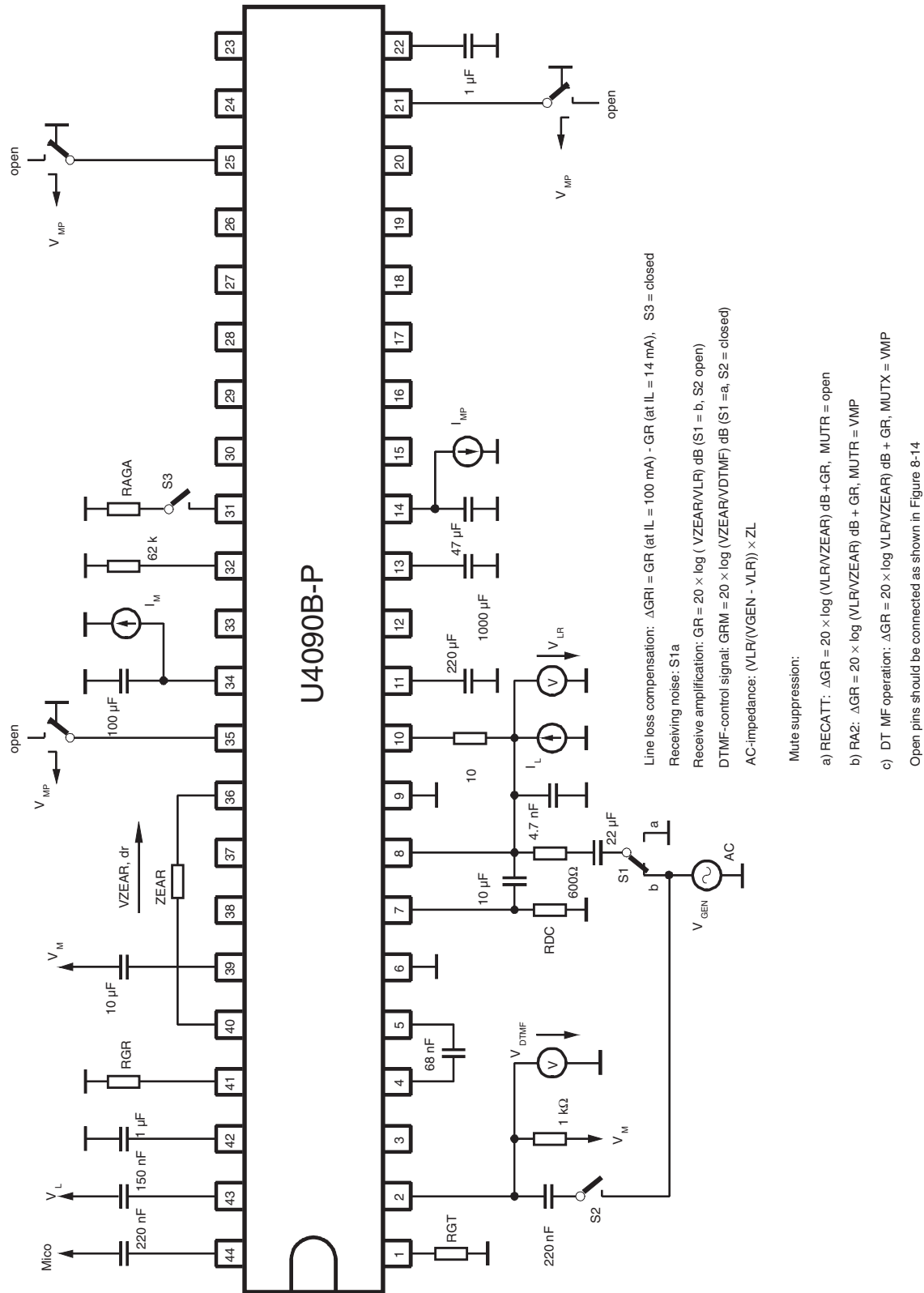




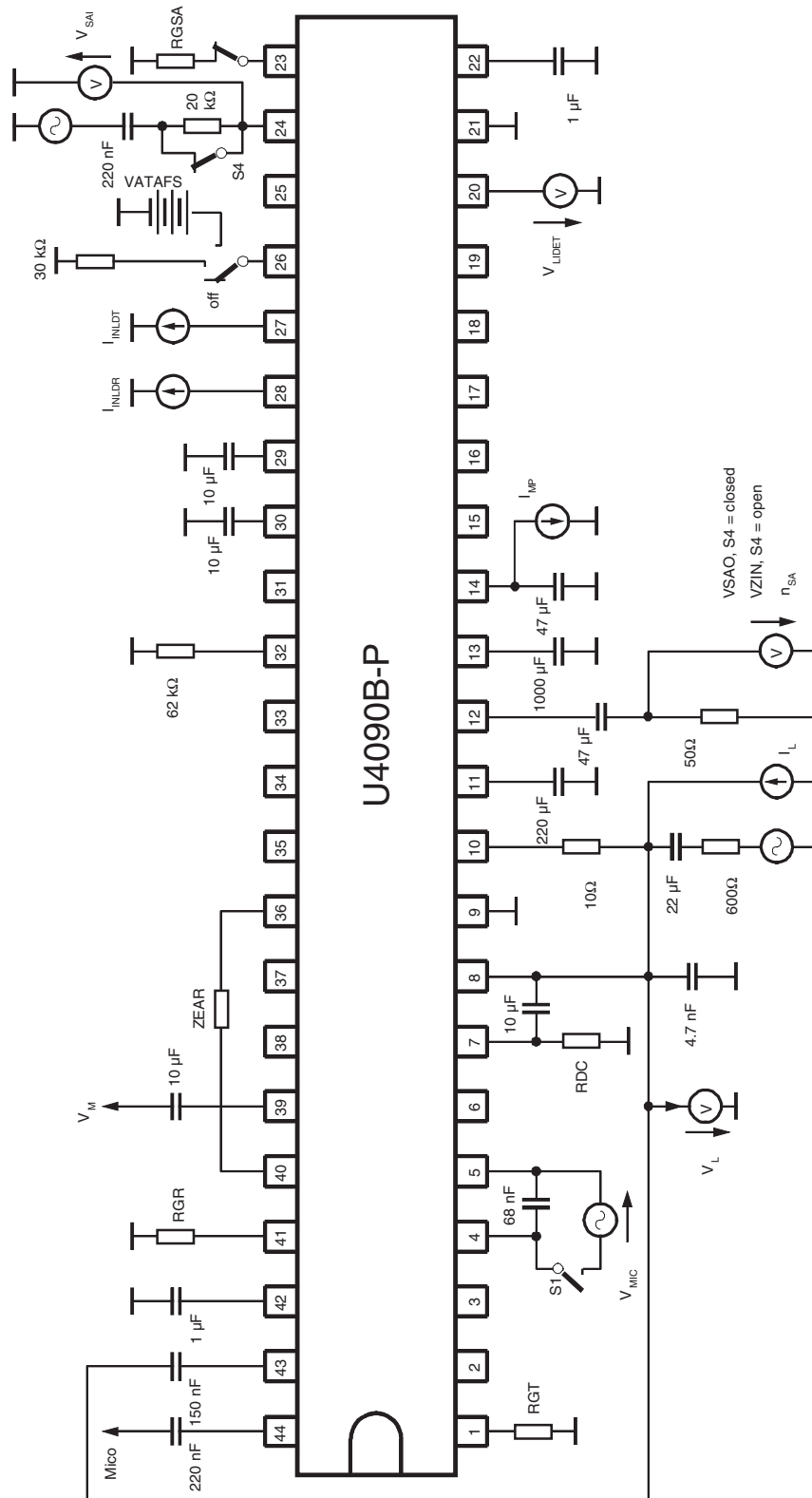
**Figure 8-10. Test Circuit for Transmission Amplifier**



**Figure 8-11. Test Circuit for Receiving Amplifier**

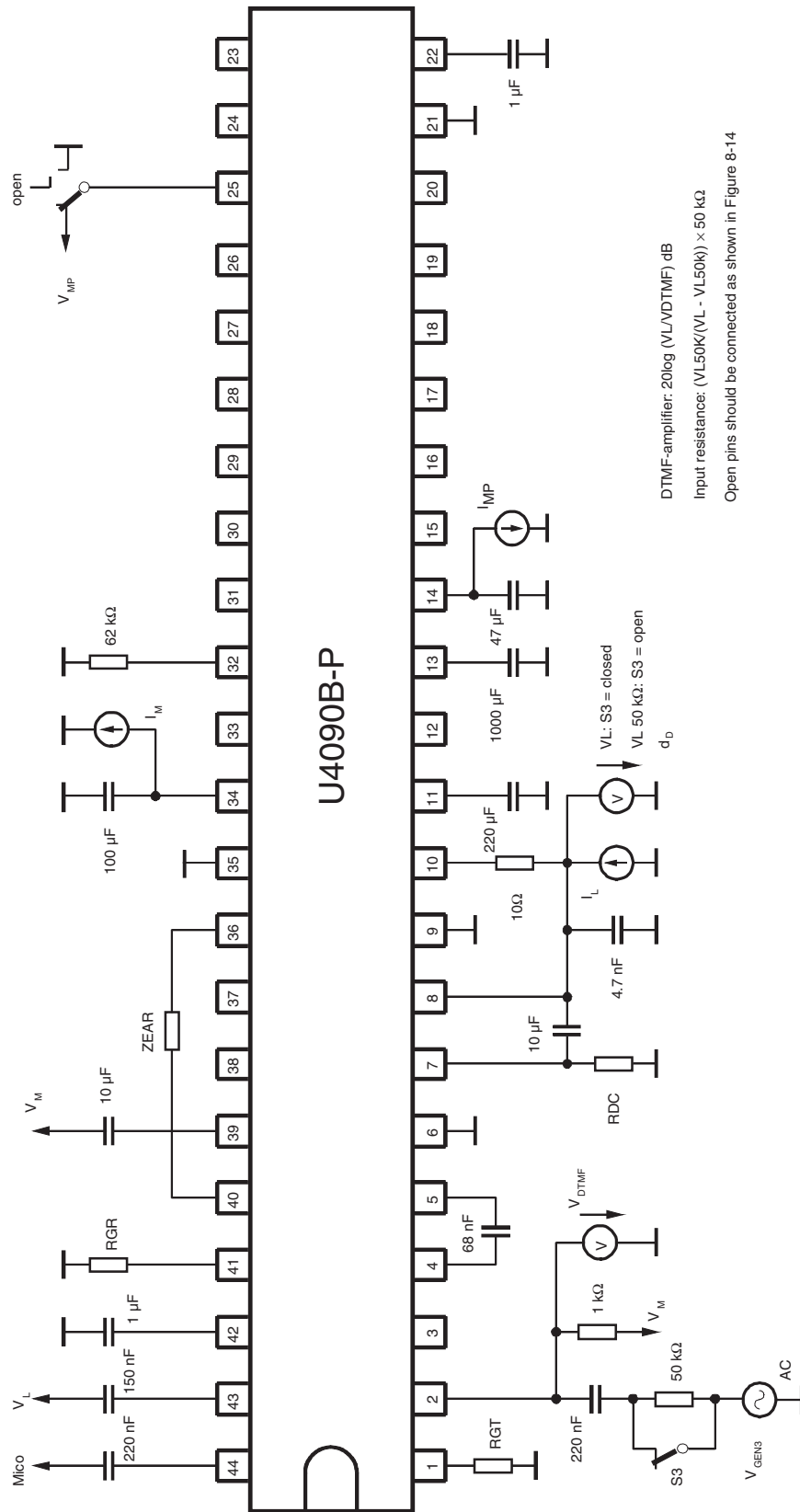


**Figure 8-12. Test Circuit for Speaker Amplifier**

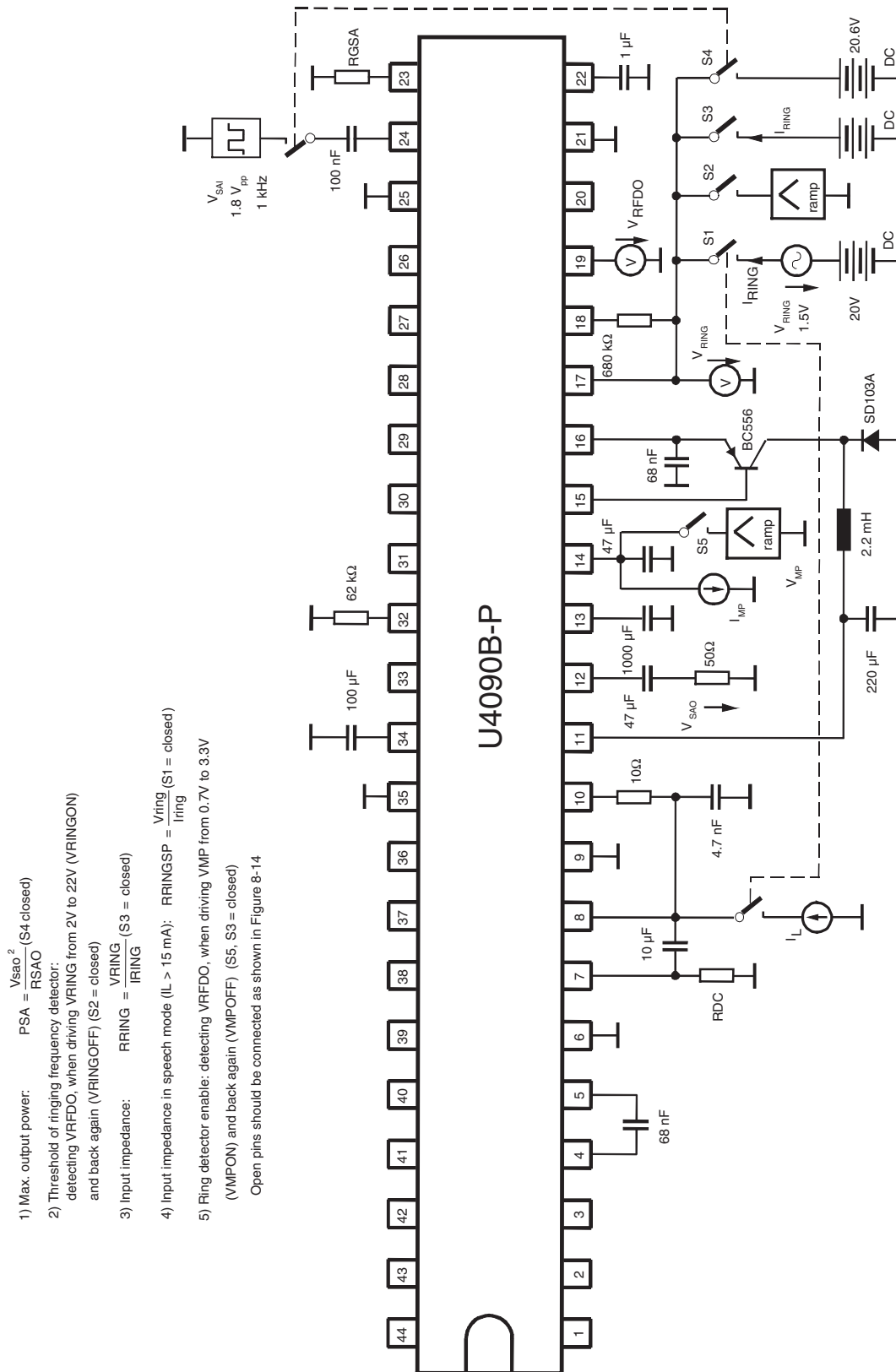


Input impedance:  $(V_{ZIN}/(V_{SAO} - V_{ZIN})) \times R_{IN}$   
 Gain from SAI to SAO:  $20 \times \log (V_{SAO}/V_{SAI})$  dB  
 Output power:  $PSA = \frac{V_{SAO}^2}{R_{SAO}}$   
 Attenuation of transmit gain: S1 = closed  
 Open pins should be connected as shown in Figure 8-14

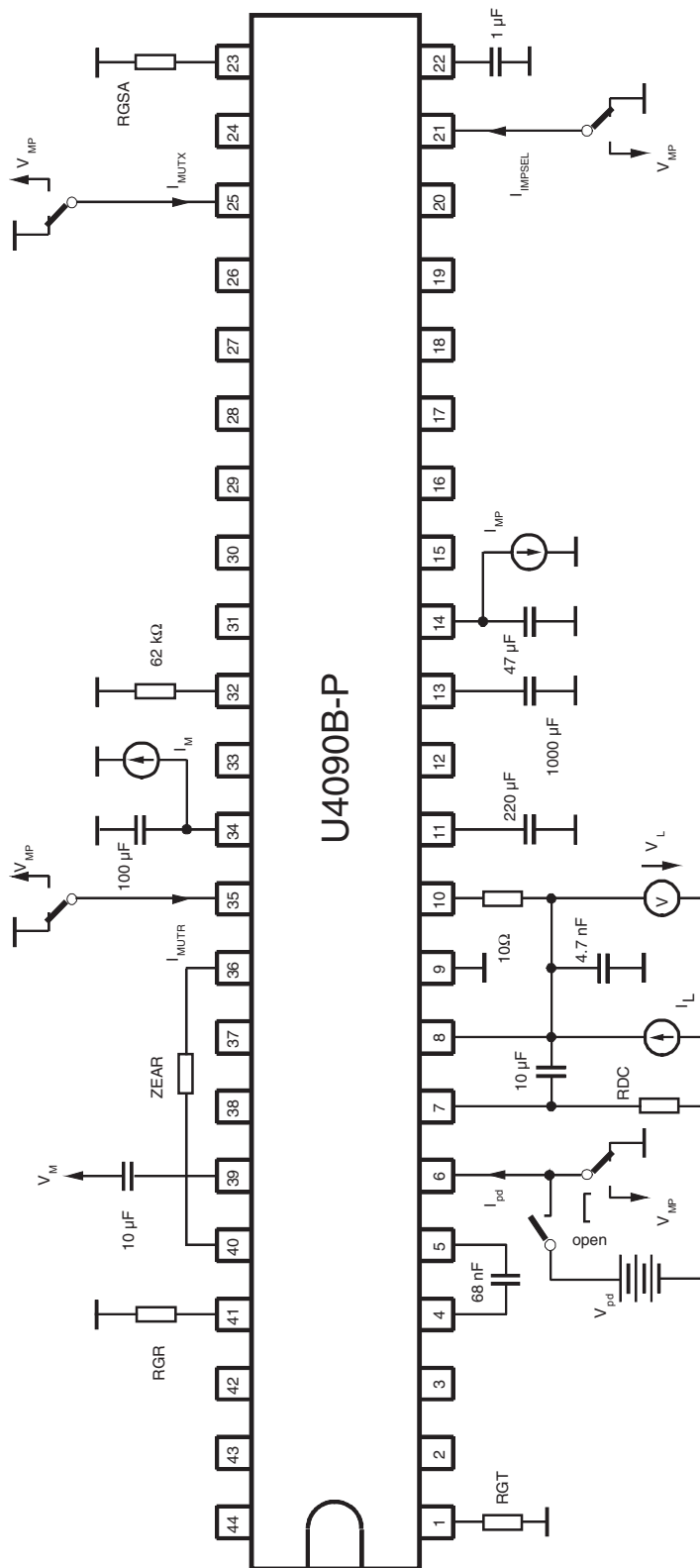
**Figure 8-13.** Test Circuit for DTMF Amplifier



**Figure 8-14.** Test Circuit for Ringing Power Converter

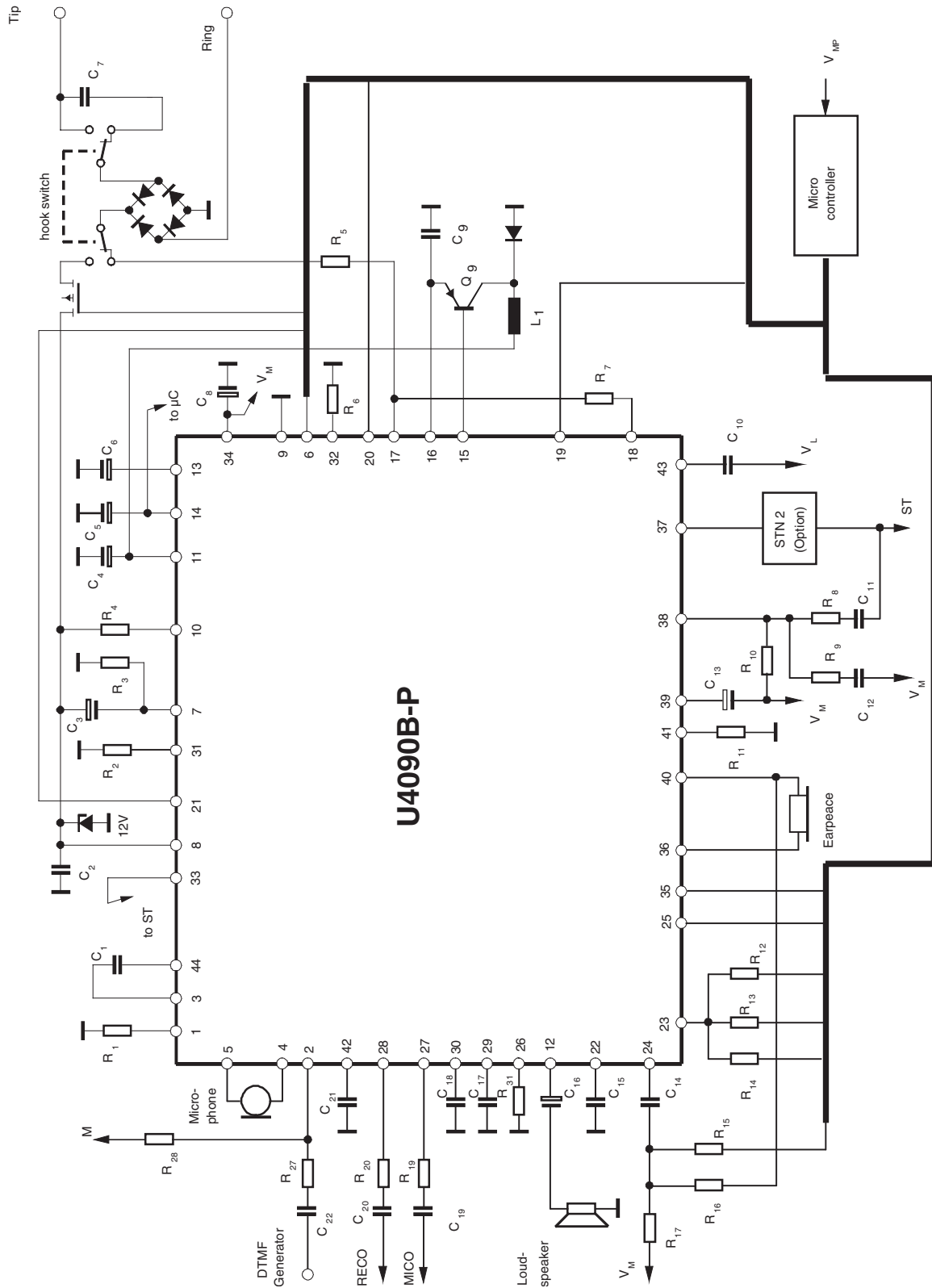


**Figure 8-15.** Test Circuit for Input Characteristics of I/O Ports

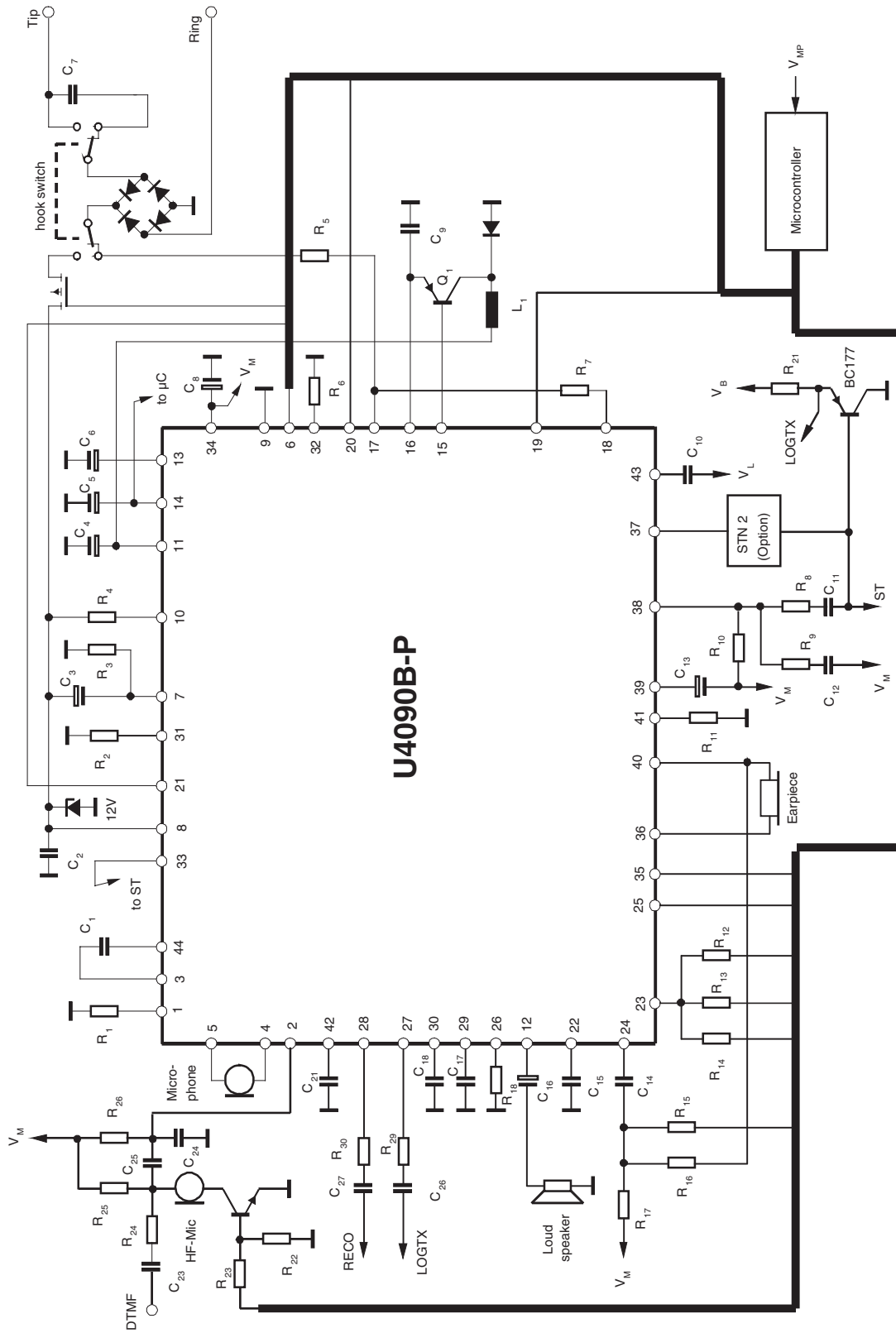


Open pins should be connected as shown in Figure 8-14

Figure 8-16. Application Circuit for Loud-hearing



**Figure 8-17.** Application for Hands-free Operation





**Table 8-1.** Typical Values of External Components (Figure 8-16 on page 31 and Figure 8-17 on page 32)

Name	Value	Name	Value	Name	Value	Name	Value
C <sub>1</sub>	100 nF	C <sub>16</sub>	47 μF	R <sub>3</sub>	> 68 kΩ	R <sub>18</sub>	30 kΩ
C <sub>2</sub>	4.7 nF	C <sub>17</sub>	10 μF	R <sub>4</sub>	10 kΩ	R <sub>19</sub>	6.8 kΩ
C <sub>3</sub>	10 μF	C <sub>18</sub>	10 μF	R <sub>5</sub>	1.5 kΩ	R <sub>20</sub>	6.8 kΩ
C <sub>4</sub>	220 μF	C <sub>19</sub>	68 nF	R <sub>6</sub>	62 kΩ	R <sub>21</sub>	15 kΩ
C <sub>5</sub>	47 μF	C <sub>20</sub>	68 nF	R <sub>7</sub>	680 kΩ	R <sub>22</sub>	330 kΩ
C <sub>6</sub>	470 μF	C <sub>21</sub>	1 μF	R <sub>8</sub>	22 kΩ	R <sub>23</sub>	220 kΩ
C <sub>7</sub>	820 nF	C <sub>22</sub>	100 nF	R <sub>9</sub>	330 kΩ	R <sub>24</sub>	68 kΩ
C <sub>8</sub>	100 μF	C <sub>23</sub>	6.8 nF	R <sub>10</sub>	3 kΩ	R <sub>25</sub>	2 kΩ
C <sub>9</sub>	100 nF	C <sub>24</sub>	10 nF	R <sub>11</sub>	62 kΩ	R <sub>26</sub>	3.3 kΩ
C <sub>10</sub>	150 nF	C <sub>25</sub>	100 nF	R <sub>12</sub>	30 kΩ	R <sub>27</sub>	18 kΩ
C <sub>11</sub>	86 nF	C <sub>26</sub>	470 nF	R <sub>13</sub>	62 kΩ	R <sub>28</sub>	2 kΩ
C <sub>12</sub>	33 nF	C <sub>27</sub>	33 nF	R <sub>14</sub>	120 kΩ	R <sub>29</sub>	1 kΩ
C <sub>13</sub>	10 μF	L <sub>1</sub>	2.2 mH	R <sub>15</sub>	47 kΩ	R <sub>30</sub>	12 kΩ
C <sub>14</sub>	100 nF	R <sub>1</sub>	27 kΩ	R <sub>16</sub>	1 kΩ	R <sub>31</sub>	56 kΩ
C <sub>15</sub>	1 μF	R <sub>2</sub>	20 kΩ	R <sub>17</sub>	1.2 kΩ		

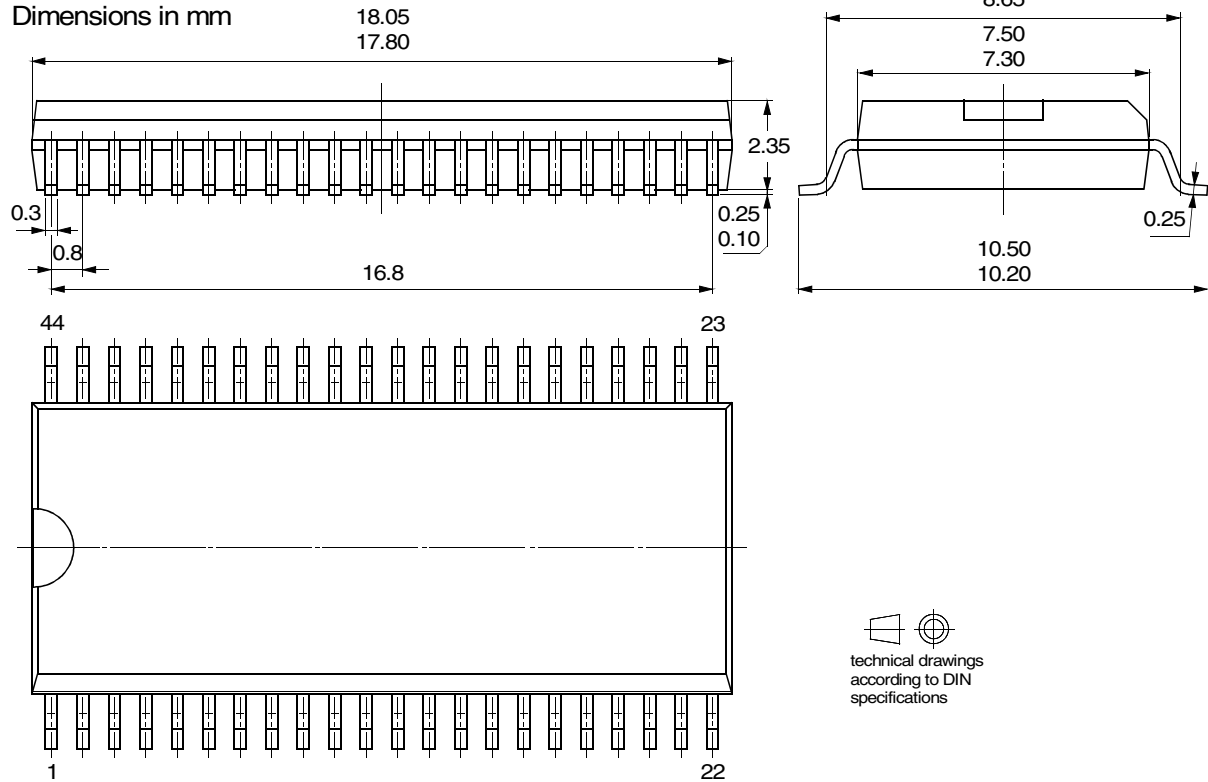
## 9. Ordering Information

Extended Type Number	Package	Remarks
U4090B-PFNY	SSO44	Pb-free
U4090B-PFNG3Y	SSO44	Taped and reeled, Pb-free
T4090B-PC	Die	Chip on foil

## 10. Package Information

### Package SSO44

Dimensions in mm





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