

Telephone Speech Circuit

Description

The U4030B is an electronic speech circuit for standard and feature telephones. It replaces the hybrid transformer, earphone and microphone interface and the supply voltage generation for external components, e.g. dialer or microcomputers. Using the U4030B in telephone circuit

designs can improve transmission quality and results in cost savings through shorter and more flexible design procedures. It reduces the amount of external components needed. The U4030B uses TEMIC's reliable BIPOLAR technology and is offered in a DIP 20 or SO 20 package.

Features

- Microphone amplifier with
 - Symmetrical input
 - Privacy function
 - Anticlippping
- Built in ear protection
- Power down input
- Mute input
- DTMF interface
- Low line impedance during pulse dialing

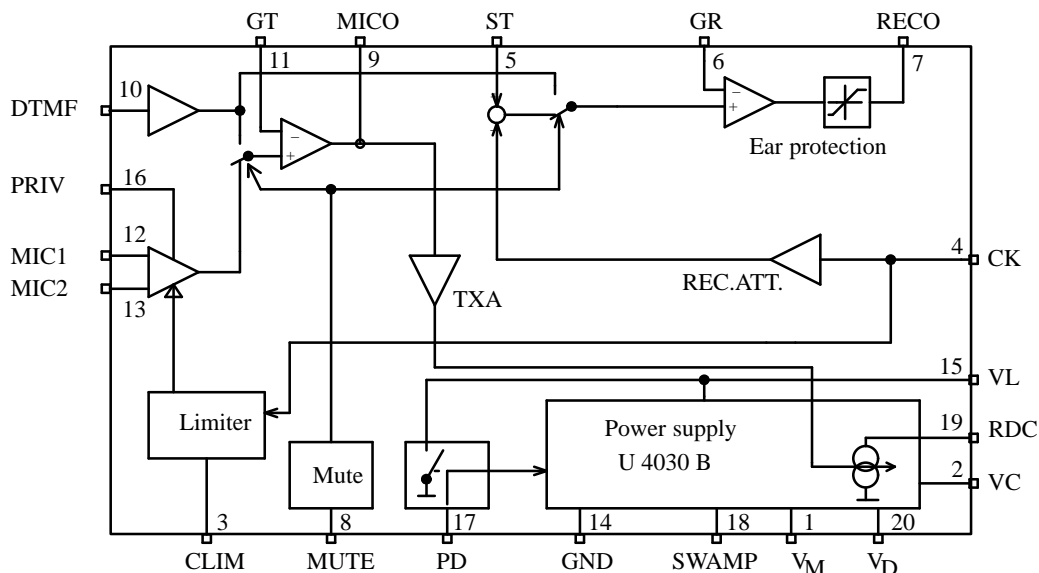
Benefits

- Independent adjustment of
 - Transmission gain
 - Receiving gain
 - Sidetone suppression
 - Frequency response
- Low-impedance supply voltage for all external blocks
- Supply voltage for an electret microphone

Applications

- Standard telephone
- Fax machine
- Answering machine
- Cordless telephone

Block Diagram



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Figure 1

Pin Description

Pin	Symbol	Function
1	V_M	Supply voltage for an electret microphone, virtual ground
2	V_C	The internal 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 line voltage
3	CLIM	Time constant of antialiasing in trans. path
4	CK	Input of receive amplifier
5	ST	Input of side tone amplifier, must be dc-coupled to V_M
6	G_R	Input for receive gain control
7	RECO	Output of receiving amplifier
8	MUTE	Active high input to switch circuit in DTMF-condition
9	MICO	Output of microphone amplifier
10	DTMF	Input for DTMF signals (ac-coupled). In mute condition a small portion of the signal at this pin is monitored to the receive output
11	G_T	Input for transmit gain control

Pin	Symbol	Function
12	MIC1	Inverting input of microphone amplifier
13	MIC2	Non-inverting input of microphone amplifier
14	GND	Ground (reference point for dc and ac signals)
15	V_L	Line voltage
16	PRIVACY	Active high input to disable microphone amplifier
17	PD	Power down input. Active high input for reducing the current consumption of the circuit. Simultaneously V_L is shorted by an internal switch
18	SWAMP	A resistor connected from this point to ground converts the excess line current into heat in order to prevent the IC from thermal destruction at high line currents
19	RDC	Input of power supply
20	V_D	Unregulated supply voltage for peripheral circuits. Output current capability and output voltage increase with line current

Circuit Description

Reference for all descriptions is figure 9, unless otherwise specified.

Power Supply

DC characteristic

The power supply stage determines the voltage/current characteristic of the circuit. The dc-slope is adjusted to 100 Ω. A resistor connected from Pin 2 to Pin 14 may be used to reduce the line voltage (figure 2).

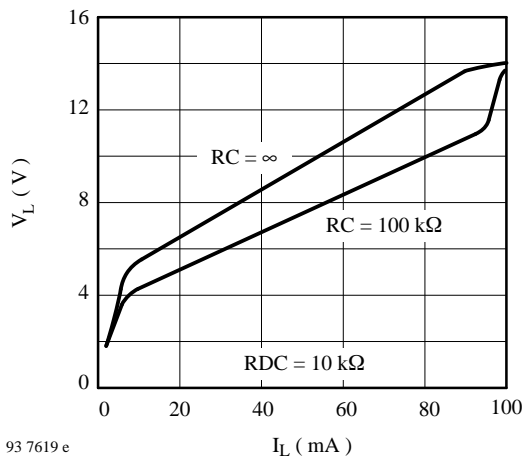


Figure 2 DC characteristics

$$V_L = (0.0033 \cdot I_{DC} + I_{\text{OFFSET}}) \cdot (R30 \parallel RC) + VRS + IR_{DC} \cdot RDC$$

with:

- $I_{\text{OFFSET}} = 150 \mu\text{A}$
- $VRS = 150 \text{mV}$
- $R30 = 30 \text{k}\Omega$
- $IDC = I_L - (750 \mu\text{A} + 0.023 \cdot I_L)$

V_D

An unregulated voltage, V_D, is generated to supply the internal and external circuits. The maximum voltage at this pin is limited by an internal Z-diode to a value of 6.2 V. The available output current is shown in figure 3.

V_M

The supply voltage for an electret microphone is derived from V_D (see figure 4). The output resistance is set to 300 Ω and the maximum output current is 300 μA. The V_M-pin is virtual ground for the receiving amplifier.

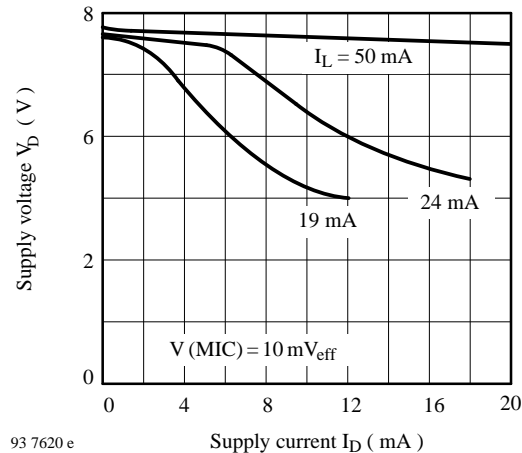


Figure 3 Supply voltage, V_D

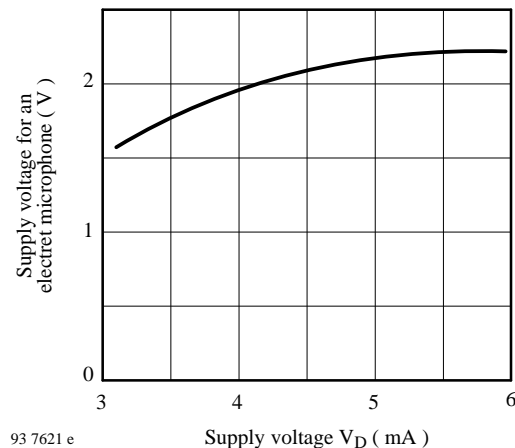


Figure 4 Electret microphone supply, V_M

Swamp

Line current which is not used for internal and external circuits is converted into heat via resistance R_{swamp} in order to prevent the IC from thermal destruction at high line currents.

The speech circuit will be high ohmic when the voltage at SWAMP reaches 6 V. Typical characteristics for various resistors are shown in figure 5.

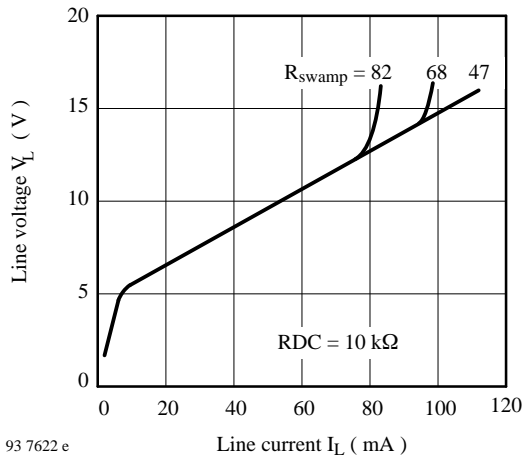


Figure 5 Typical DC characteristics for various SWAMP resistors

Charge Up Circuit

By hooking/off the handset, an integrated charge up circuit provides V_D with the whole line current. When V_D reaches 2.2 V, the charge up circuit is automatically switched off.

The specifications for the German “Bundespost” (speech readiness, start time) will be fulfilled even with 1000 μF at Pin 20.

Figure 6 illustrates the transient behavior of the circuit at $I_L = 20 \text{ mA}$.

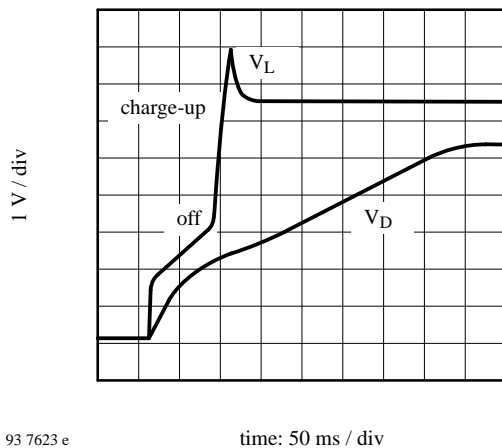


Figure 6 Charge up characteristics at $I_L = 20 \text{ mA}$

Electronic Inductance

The ac resistance ($R_{imp} 1 \text{ k}\Omega$) of the telephone should be much higher than the dc resistance (325Ω), the latter being decoupled via an electronic inductance.

The value of L is given by:

$$L = CVC \cdot RDC \cdot 30 \text{ k}\Omega \parallel R$$

where

$$\begin{aligned} RDC &= 10 \Omega \\ CVC &= 10 \mu\text{F} \\ R30 &= 30 \text{ k}\Omega \\ RC &= \text{infinite} \\ L &= 3 \text{ H} \end{aligned}$$

Transmit

Microphone amplifier

The microphone amplifier of U4030B has symmetrical inputs (MIC1 and MIC2) with an input resistance of $60 \text{ k}\Omega$ (typical). It has a gain of 29 dB which is adjustable with resistances RS1 and RS2 as follows:

$$\begin{aligned} G_T &= V_{\text{MICO}} / V_{(\text{MIC1}, \text{MIC2})} \\ &= 20 \log[(RS1 / RS2) + 1] \text{ dB} \end{aligned}$$

A low pass function can be realised with CSLP. The corner frequency is given by:

$$f_C = 1 / (2 \pi RS1 \text{ CSLP})$$

When the ac level on V_L is very high, the amplification of the microphone is reduced by the limiter function. The threshold of the limiter is fixed at 5.5 dBm (typical).

DTMF

The amplification of the DTMF signal is determined by the ratio of RS1 and RS2 as follows:

$$\begin{aligned} G_D &= V_{\text{MICO}} / V_{\text{DTMF}} \\ &= 20 \log\{0.19 \cdot [(RS1 / RS2) + 1]\} \end{aligned}$$

An external voltage divider is used to adjust the proper DTMF level at line.

For monitoring the dialing procedure, an attenuated DTMF signal is sent to the earpiece. The Bundespost specification is fulfilled with the nominal value of the transmit and receive gain.

Transmit Output Amplifier

The output signal of the microphone and DTMF preamplifier is internally coupled to a second amplifier (TXA) which is used to modulate a controlled current source. Assuming a termination of $600\ \Omega$ at a line, the gain from MICO to V_L is typically 15.6 dB.

Receive Amplifier

The receive signal is taken from line via capacitor C_{CK} . A resistive attenuator ($-32\ \text{dB}$) sets the appropriate input level for the following output amplifier. The input impedance at Pin 4 is typically $80\ \text{k}\Omega$.

Voltage gain is:

$$\begin{aligned} G_R &= 20 \log (V_{\text{ear}} / V_L) \text{ dB} \\ &= -32 \text{ dB} + 20 \log [(RR1 / RR2) + 1] \text{ dB} \\ &= +1.8 \text{ dB} \end{aligned}$$

The adjustment range for receive gain G_R is typically $-4\ \text{dB}$ to $+8\ \text{dB}$.

The built-in ear protection limits the output swing at Pin 7 to $2.4\ \text{V}_{pp}$ ($V_D > 4\ \text{V}$). For high receive gain, the maximum undistorted output level might not be sufficient due to clipping by ear protection.

Side Tone

The amplified microphone signal is available at the input of the side tone loop, MICO. The loop consists of a transmit amplifier (transconductance STX), the impedance at line, receive attenuator (gain) and the side tone network (figure 7).

The side tone cancellation is achieved by comparing a part of the line signal with the output of the side tone network ($V_{ST} \rightarrow V_R$). Assuming a real impedance of the telephone (R_{Tel}) the optimum side tone network can be calculated:

$$\begin{aligned} a &= (S_{TX} \cdot R_{APP} \cdot G) / (1 - S_{TX} \cdot R_{APP} \cdot G) \\ Z_{NW} &= S_{TX} \cdot R \cdot G \cdot Z_{Line} \end{aligned}$$

Adjustment to the sensitivities of the handset can be done independently from the side tone network because receive and transmit gain are set outside of the side tone loop.

Power Down (PD)

The speech circuit is switched low ohmic by selecting a high level at PD during the pulse dialling. The voltage drop across the IC will be typically $1.5\ \text{V}$. During this time the capacitor C_{VD} will not be discharged, because an internal power down switches off all internal amplifiers. In order to avoid cracks, it is recommended to activate power down while sending the dial pulses (figure 8).

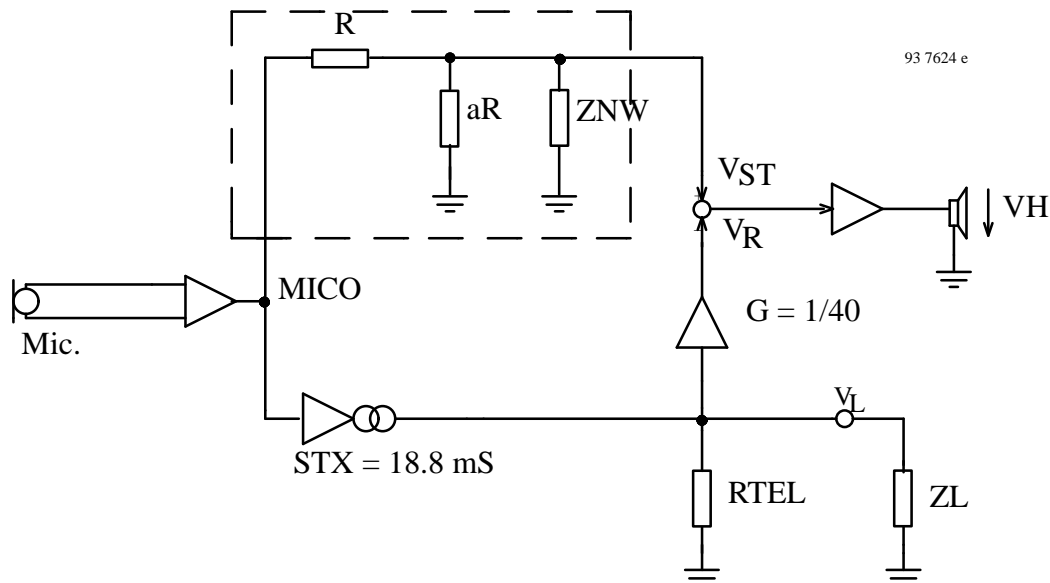
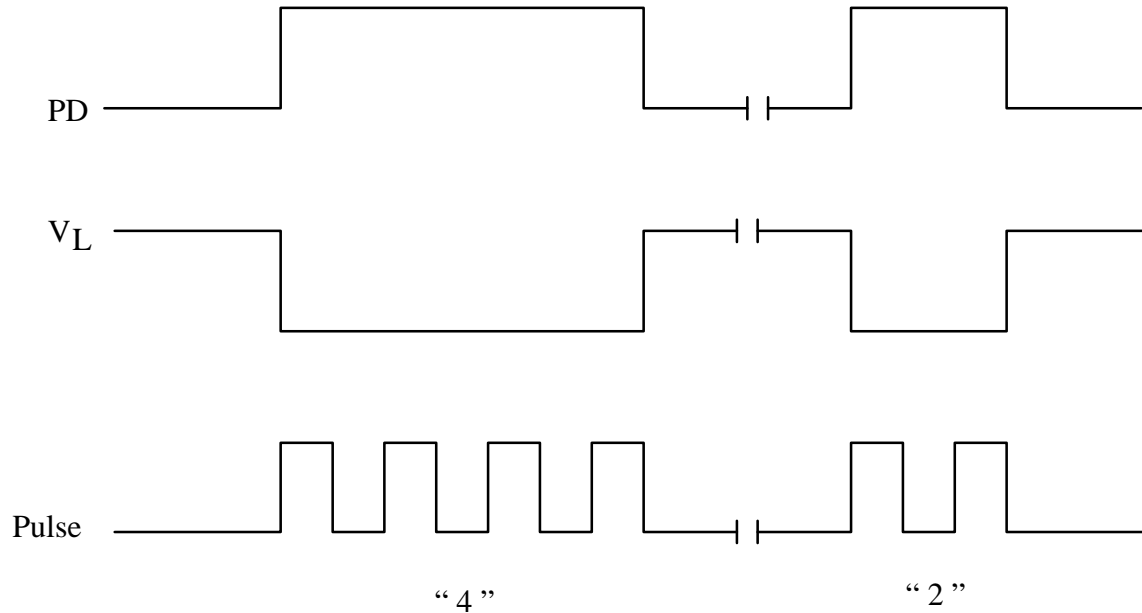


Figure 7 Schematic of the side tone



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Figure 8 Recommended timing diagram for power down diagram

Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Line current (according to figure 9)	I_L	200	mA
DC line voltage	V_L	16	V
Storage temperature range	T_{stg}	-55 to +150	°C
Junction temperature	T_j	150	°C
Ambient temperature range	T_{amb}	-25 to +65	°C
Power dissipation			
DIP 20	P_{tot}	820	mW
SO 20	P_{tot}	640	mW
$T_{amb} = 60\text{ °C}$			

Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient			
DIP 20	R_{thJA}	110	K/W
SO 20	R_{thJA}	140	K/W

Electrical Characteristics

f = 1000 Hz, T_{amb} = 25°C, reference point Pin 14, unless otherwise specified.

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit	
DC characteristics (figure 9)							
DC voltage in speech mode	I _L = 19 mA	V _L	6.2	6.5	6.8	V	
	I _L = 26 mA						7.2
	I _L = 60 mA						10.0
Transmit amplifier and sidetone reduction (figure 10)							
Input resistance		R _I	45.0	60.0	80.0	kΩ	
Transmit gain	I _L = 24 mA	G _T	44.2	44.7	45.2	dB	
Gain variation	19 mA ≤ I _L ≤ 60 mA	ΔG _T	-0.5		+0.5	dB	
Noise at line, psophometrically weighted	R _L = 600 Ω Z _{RECO} = 68 nF Z _{MIC} = 68 nF I _L = 19 to 60 mA	n _O			-75.0	dBmp	
Sidetone gain (figure 10)							
Max. output voltage	R _L → ∞ d ≤ 5 % V _{MIC} = 5.4 mV	V _{Omax}		5.5	6.3	dBm	
Common mode rejection ratio		CMRR		80.0		dB	
Mute: reduction of voltage amplification	Z _{RECO} = 68 nF		60.0			dB	
Privacy: reduction of voltage amplification			60.0			dB	
Receiving amplifier (figure 11)							
Gain	Z _{RECO} = 68 nF I _L = 24 mA	G _R	-3.9	-3.4	-2.9	dB	
Gain variation	19 mA ≤ I _L ≤ 60 mA	ΔG _R	-0.5		0.5	dB	
Noise at earphone psophometrically weighted	I _L = 19 to 60 mA Load T, R = 600 Ω Z _{RECO} = 68 nF Z _{MIC} = 68 nF	n _I			-78	dBmp	
Max. output voltage	I _L = 19 to 60 mA Z _{RECO} = 68 nF d ≤ 2 %	V _{Omax}	600	650		mVrms	
Switching threshold of ear protection	I _L = 19 to 60 mA Z _{RECO} = 68 nF V _{GEN} = 3 Vrms		0.7		1.3	Vrms	
Voltage amp. from DTMF to RECO	Z _{ear} = 68 nF		-7	-4	-1	dB	
Output impedance					10	Ω	
Power down (figure 12)							
PD-off input voltage		V _I			0.3	V	
PD-on input voltage		V _I	2			V	
Input current	V _I = 6 V	I _I			130	μA	
Line voltage	PD on, I _L = 24 mA	V _L		1.5		V	
Input current consumption at V _D	PD on	I _D			100	μA	

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Mute input, (figure 12)						
MUTE input current	$V_{MUTE} = 6\text{ V}$ $V_{MUTE} = 0.3\text{ V}$	I_{MUTE}			120 -25	μA μA
MUTE-off input voltage		V_{MUTE}			0.3	V
MUTE-on input voltage		V_{MUTE}	1.5			V
Supply voltages (figure 10)						
Output voltage	$I_L = 19\text{ mA}$ $I_D = 4.5\text{ mA}$ $V_{MIC} = 10\text{ mV}$ $I_L = 50\text{ mA}$ $I_D = 15\text{ mA}$ $V_{MIC} = 10\text{ mV}$	V_D	4.0 5.5	4.5	 6.2	V V
Output voltage	$I_L = 19\text{ mA}$ $I_D = 3\text{ mA}$ $I_M = 300\text{ }\mu\text{A}$	V_M		2.2		V
Output current		I_M			300	μA
Output resistance		R_O		300		Ω
DTMF-amplifier (figure 12)						
Input resistance		R_D	22	31	37	$\text{k}\Omega$
DTMF-gain	Load = Z_R $0 < R_v < 1530\text{ }\Omega$	G_D	24.7	26	27	dB
Max. output voltage	$I_L = 19\text{ to }60\text{ mA}$ Load = Z_R $d \leq 2\%$		1.8			V_{rms}
Privacy (figure 12)						
PRIV-on input voltage		V_{PRIV}	2			V
PRIV-off input voltage		V_{PRIV}			0.8	V
Input current	$V_{PRIV} = 6\text{ V}$	I_{PRIV}			60	μA

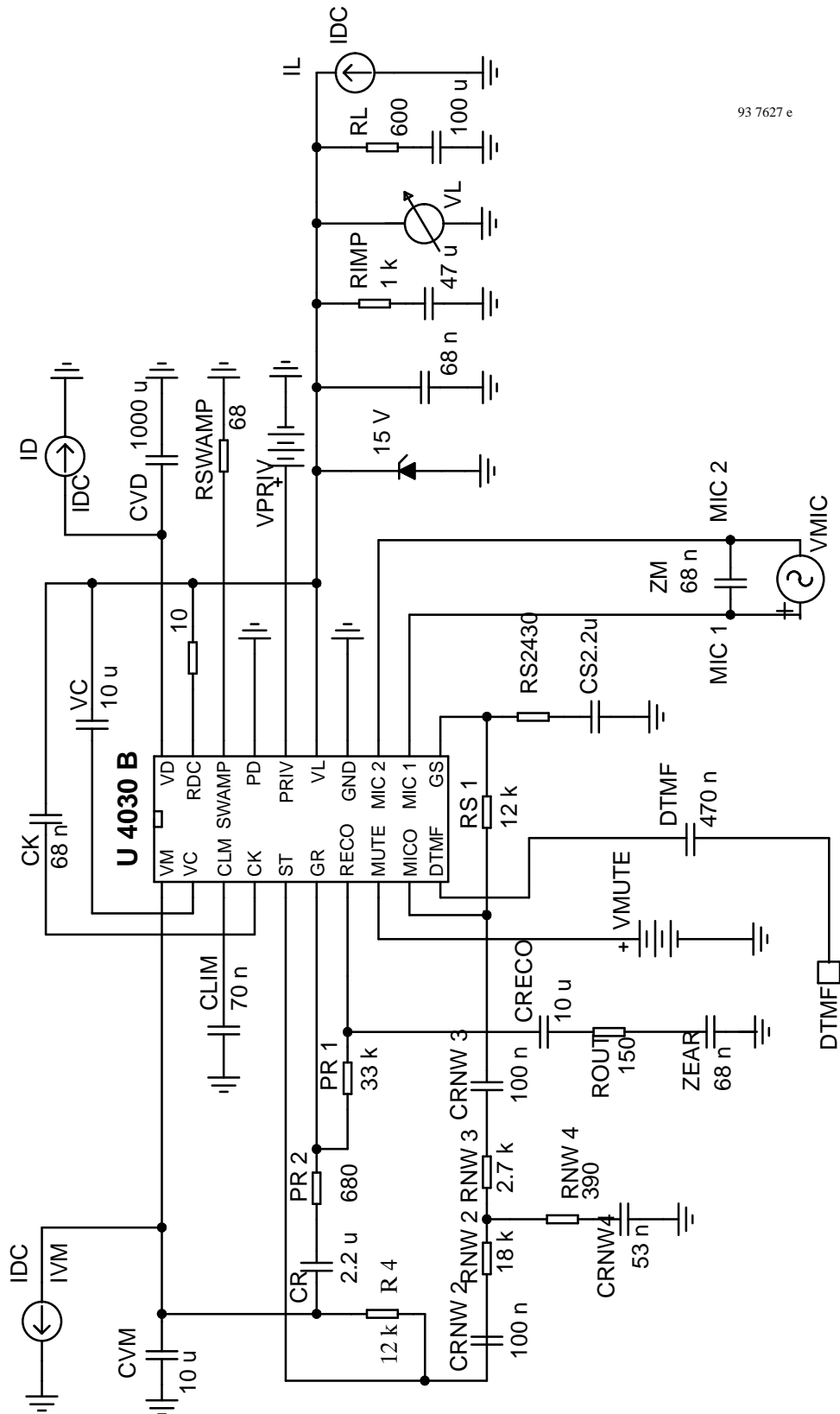
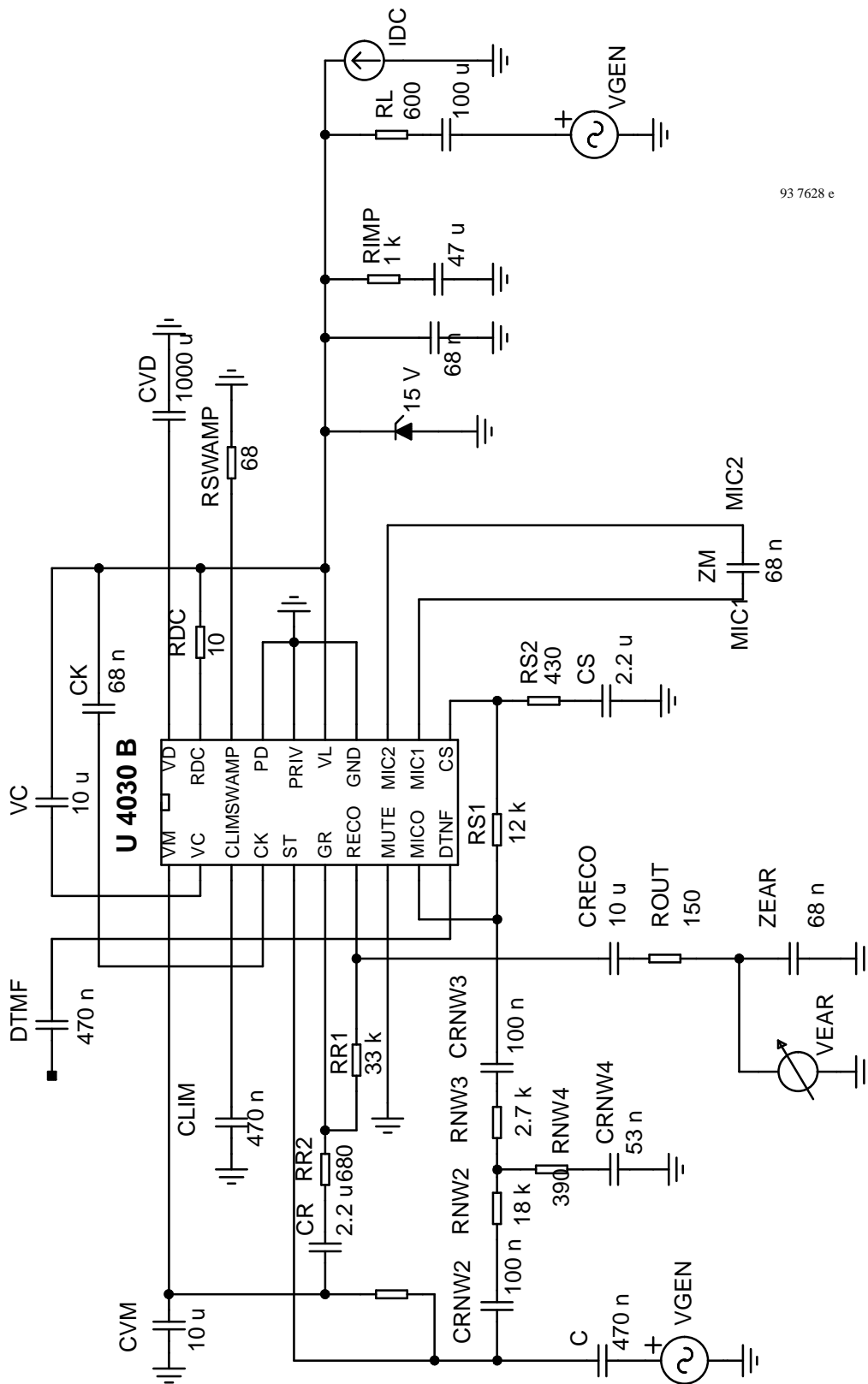
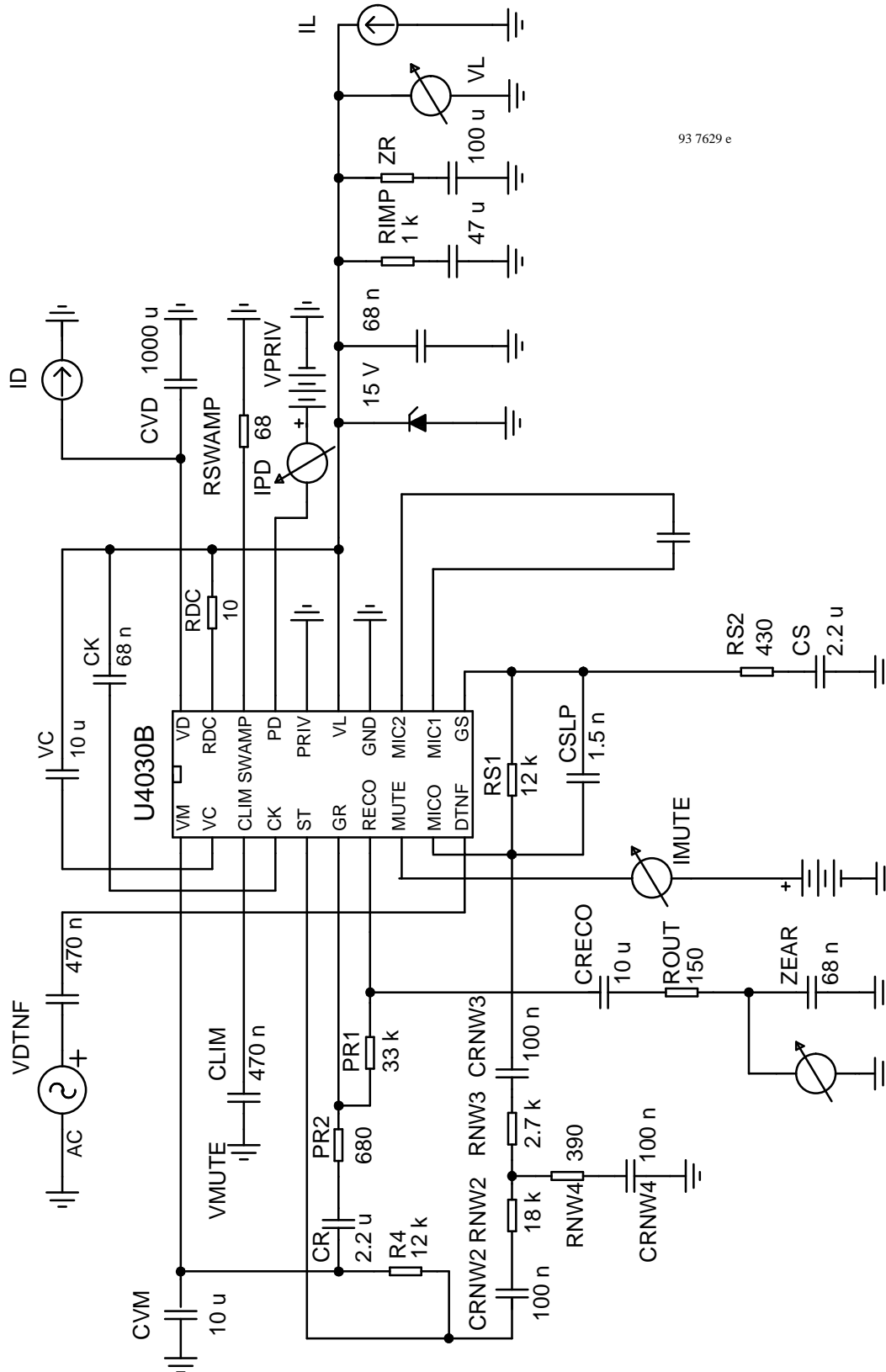


Figure 10 Transmit gain



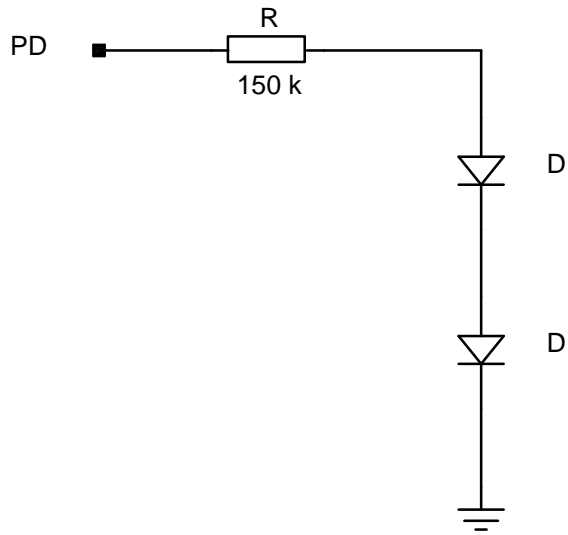
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Figure 11 Receiving gain and sidetone amplification



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Figure 12 DTMF gain



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Figure 13 PD input

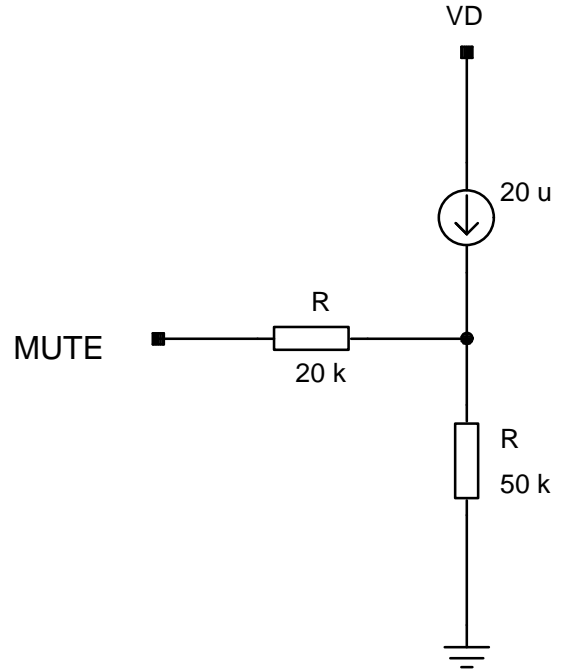
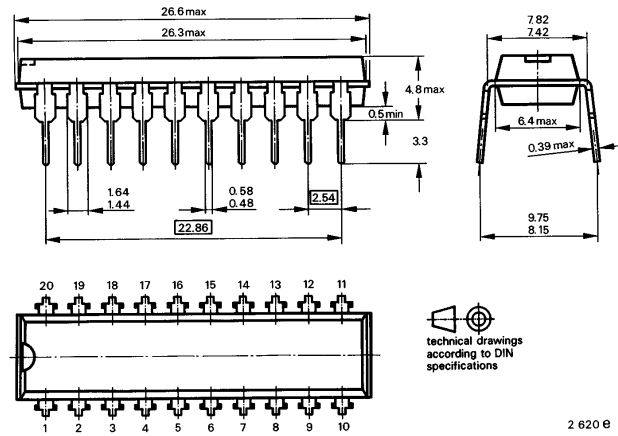


Figure 14 Mute input

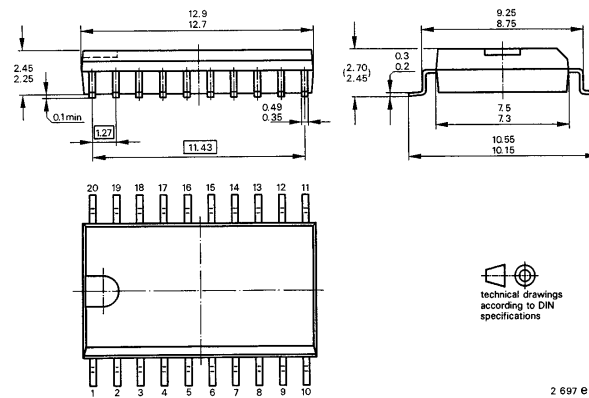
U4030B

Dimensions in mm

Package: DIP 20



Package: SO 20



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1. Meet all present and future national and international statutory requirements.
2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

The Montreal Protocol (1987) and its London Amendments (1990) intend to severely restrict the use of ODSs and forbid their use within the next ten years. Various national and international initiatives are pressing for an earlier ban on these substances.

TEMIC TELEFUNKEN microelectronic GmbH semiconductor division has been able to use its policy of continuous improvements to eliminate the use of ODSs listed in the following documents.

1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively
2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA
3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

TEMIC can certify that our semiconductors are not manufactured with ozone depleting substances and do not contain such substances.

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