# TEMIC
Semiconductors

# U4030B

## 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 DIP20 or SO20 package.

## Features

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

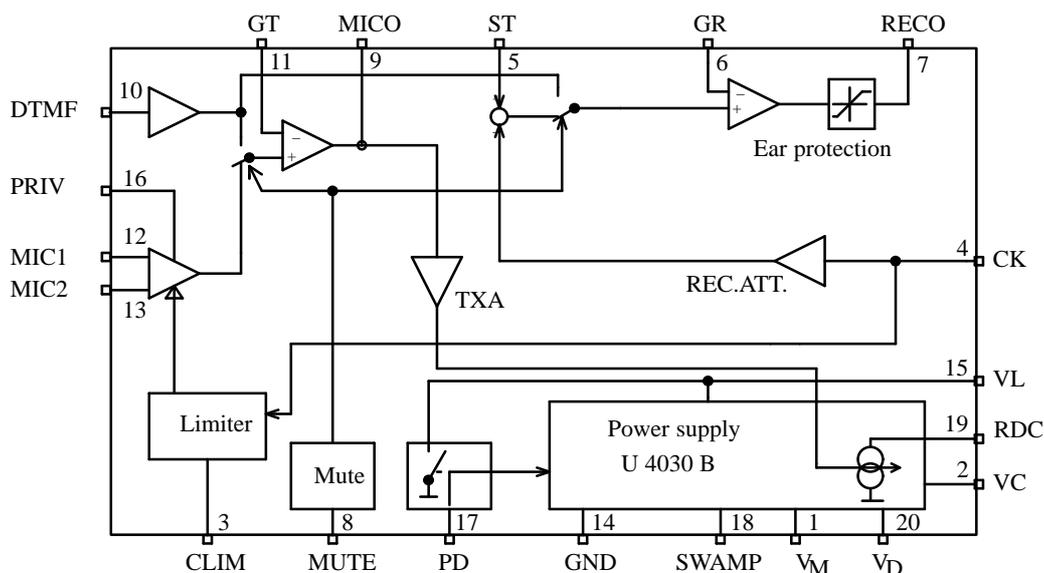## Benefits

- 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



Figure 1.

Preliminary Information

## Pin Description

| Pin | Symbol | Function |
|---|---|---|
| 1 | $V_M$ | Supply voltage for an elecret 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 anticlipping 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 |

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## 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 $\Omega$. A resistor connected from Pin 2 to Pin 14 may be used to reduce the line voltage ( figure 2 ).
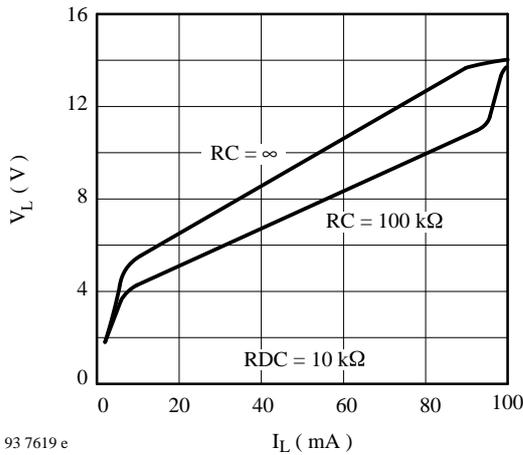


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Figure 2. DC characteristics

$$V_L = (0.0033 \times I_{DC} + I_{OFFSET}) \times (R30 \| RC) + VRS + IRDC \times RDC$$

with:

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

## $V_D$

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 $\Omega$ and the maximum output current is 300 $\mu A$. The $V_M$-pin is virtual ground for the receiving amplifier.
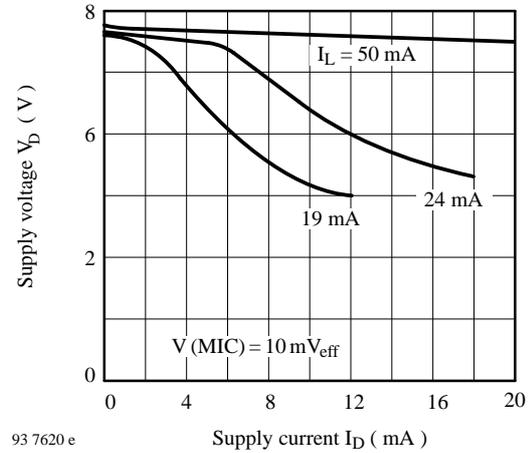


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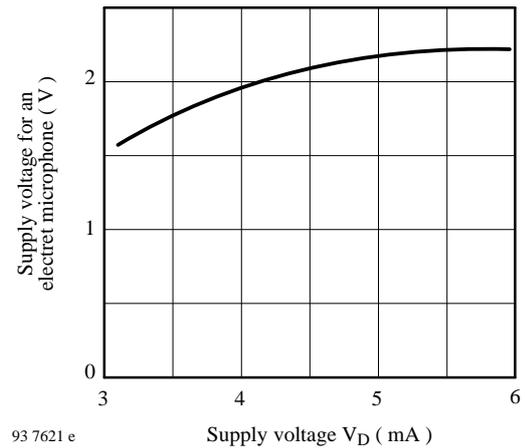Figure 3. Supply voltage, $V_D$



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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 Rswamp 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.
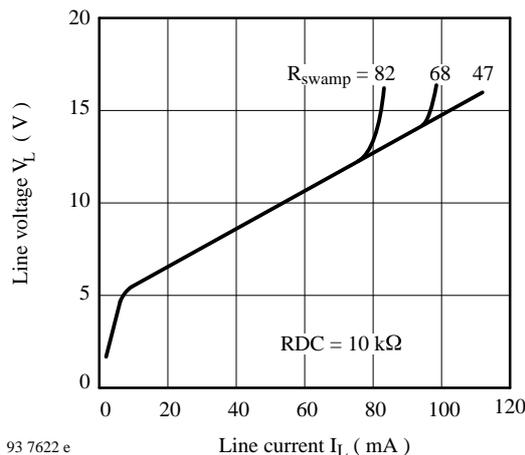
Figure 5. Typical dc characteristics for various SWAMP resistors

## 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.

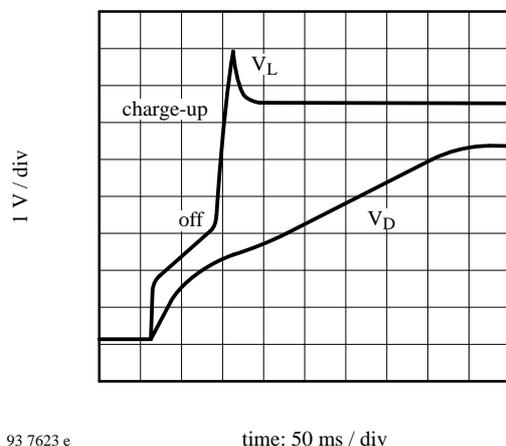Figure 6 illustrates the transient behavior of the circuit at $I_L = 20$ mA.



93 7623 e                                   time: 50 ms / div

Figure 6. Charge up characteristics at $I_L = 20$ mA

## Electronic Inductance

The ac resistance (Rimp 1 kΩ) of the telephone should be much higher than the dc resistance (325 Ω), the latter being decoupled via an electronic inductance.

The value of L is given by:

$$L = CVC \times RDC \times 30\,k\Omega \parallel R$$

where

RDC = 10 Ω
CVC = 10 μF
R30 = 30 kΩ
RC = infinite
L = 3 H

## Transmit

### Microphone amplifier

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

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

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

$$fC = 1 / (2\pi\, RS1\, CSLP)$$

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:

$$G_D = V_{MICO} / V_{DTMF}$$
$$= 20 \log \{0.19 \times [(RS1 / RS2) + 1]\}$$

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 ($-32$ dB) sets the appropriate input level for the following output amplifier. The input impedance at Pin 4 is typically 80 k$\Omega$.

Voltage gain is:

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

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

The built-in ear protection limits the output swing at Pin 7 to 2.4 $V_{pp}$ ($V_D > 4$ 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 ($VST \rightarrow VR$). Assuming a real impedance of the telephone ($R_{Tel}$) the optimum side tone network can be calculated:

$$a = (S_{TX} \times R_{APP} \times G) / (1 - S_{TX} \times R_{APP} \times G)$$
$$Z_{NW} = S_{TX} \times R \times G \times Z_{Line}$$

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.
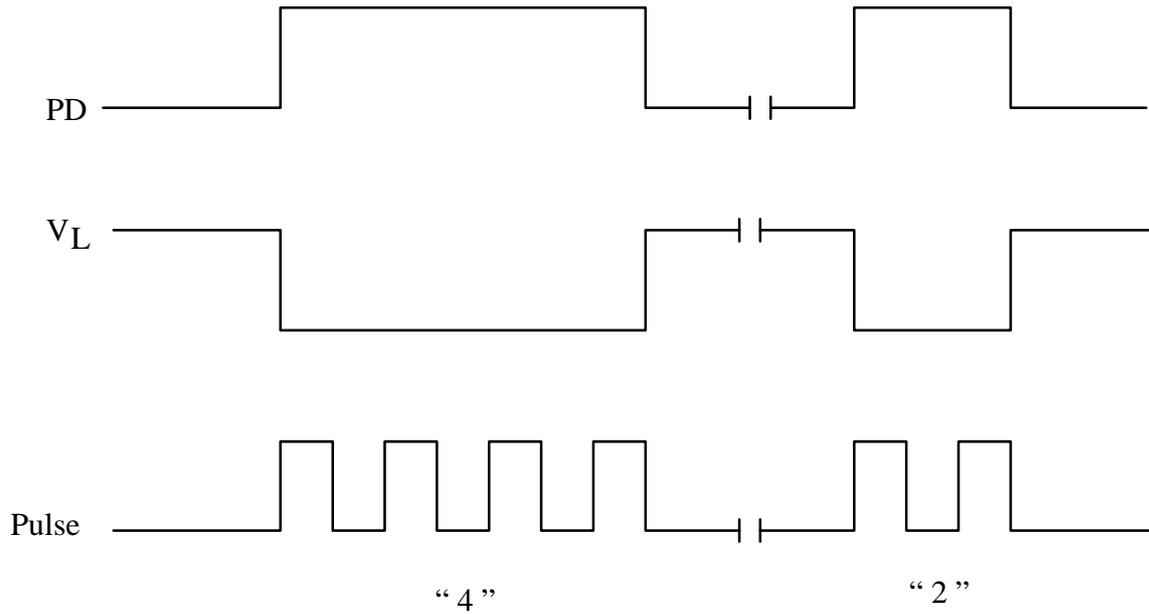
## Power Down (PD)

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 V. During this time the capacitor CVD 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).
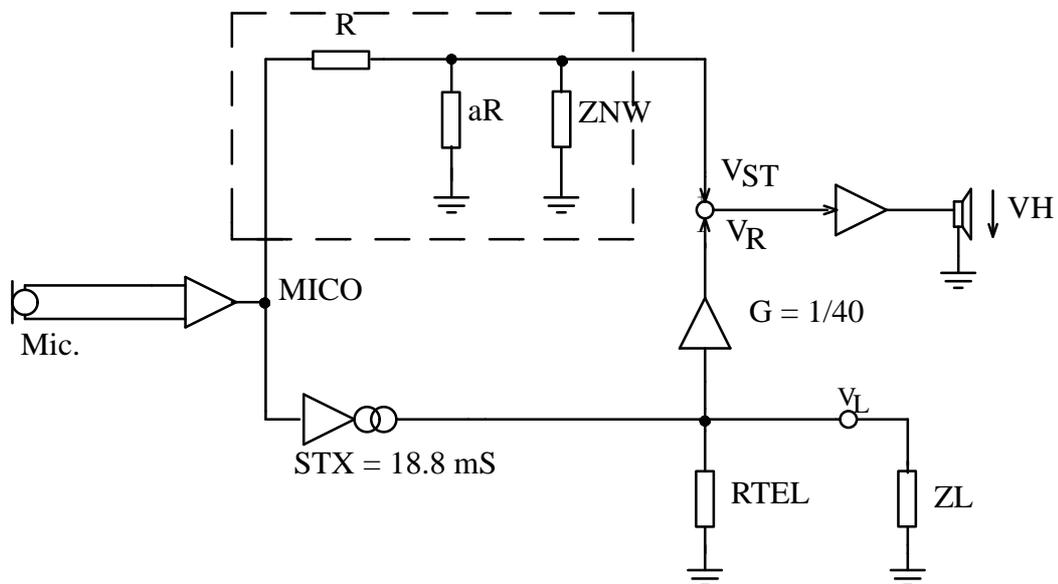


Figure 7. Schematic of the side tone

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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<br>DIP20<br>SO20<br>$T_{amb} = 60$°C | $P_{tot}$<br>$P_{tot}$ | 820<br>640 | mW<br>mW |

## Thermal Resistance

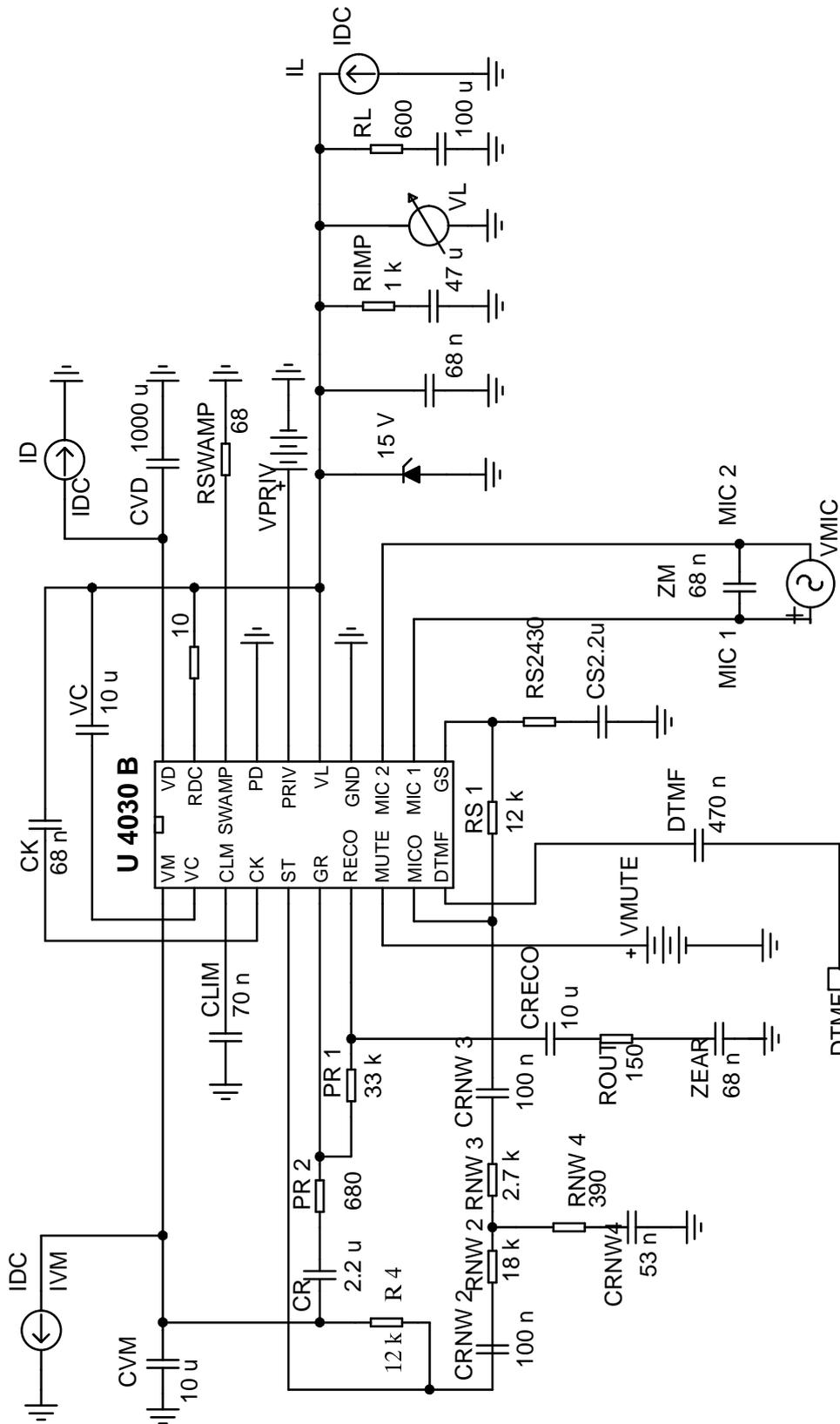| Parameters | Symbol | Value | Unit |
|---|---|---|---|
| Junction ambient<br>DIP20<br>SO20 | $R_{thJA}$<br>$R_{thJA}$ | 110<br>140 | K/W<br>K/W |

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## 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 | | V |
| | $I_L$ = 60 mA | | 10.0 | 10.5 | 11.0 | V |
| **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 | $\Delta G_T$ | −0.5 | | +0.5 | dB |
| Noise at line, psophometrically weighted | $R_L$ = 600 Ω<br>$Z_{RECO}$ = 68 nF<br>$Z_{MIC}$ = 68 nF<br>$I_L$ = 19 to 60 mA | nO | | | −75.0 | dBmp |
| **Sidetone gain (figure 10)** | | $G_{ST}$ | | 33.5 | | dB |
| Max. output voltage | $R_L \to \infty$<br>d ≦ 5%<br>$V_{MIC}$ = 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<br>$I_L$ = 24 mA | $G_R$ | −3.9 | −3.4 | −2.9 | dB |
| Gain variation | 19 mA ≦ $I_L$ ≦ 60 mA | $\Delta G_R$ | −0.5 | | 0.5 | dB |
| Noise at earphone psophometrically weighted | $I_L$ = 19 to 60 mA<br>Load T, R = 600 Ω<br>$Z_{RECO}$ = 68 nF<br>$Z_{MIC}$ = 68 nF | $n_I$ | | | −78 | dBmp |
| Max. output voltage | $I_L$ = 19 to 60 mA<br>$Z_{RECO}$ = 68 nF<br>d ≦ 2% | $V_{Omax}$ | 600 | 650 | | mVrms |
| Switching threshold of ear protection | $I_L$ = 19 to 60 mA<br>$Z_{RECO}$ = 68 nF<br>VGEN = 3 Vrms | | 0.7 | | 1.3 | Vrms |
| Voltage amp. from DTMF to RECO | Zear = 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 |

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| Parameters | Test Conditions / Pins | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Mute input, (figure 12)** | | | | | | |
| MUTE input current | $V_{MUTE} = 6$ V<br>$V_{MUTE} = 0.3$ V | $I_{MUTE}$ | | | 120<br>−25 | µA<br>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 | $I_L = 19$ mA<br>$I_D = 4.5$ mA<br>$V_{MIC} = 10$ mV<br>$I_L = 50$ mA<br>$I_D = 15$ mA<br>$V_{MIC} = 10$ mV | $V_D$ | 4.0<br><br><br>5.5 | 4.5 | <br><br><br>6.2 | V<br><br><br>V |
| Output voltage | $I_L = 19$ mA<br>$I_D = 3$ mA<br>$I_M = 300$ µA | $V_M$ | | 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 | kΩ |
| DTMF-gain | Load = $Z_R$<br>$0 < R_V < 1530$ Ω | $G_D$ | 24.7 | 26 | 27 | dB |
| Max. output voltage | $I_L = 19$ to 60 mA<br>Load = $Z_R$<br>d $\leqq$ 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 | $V_{PRIV} = 6$ V | $I_{PRIV}$ | | | 60 | µA |

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Figure 9. Application Circuit

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Figure 10. Transmit gain

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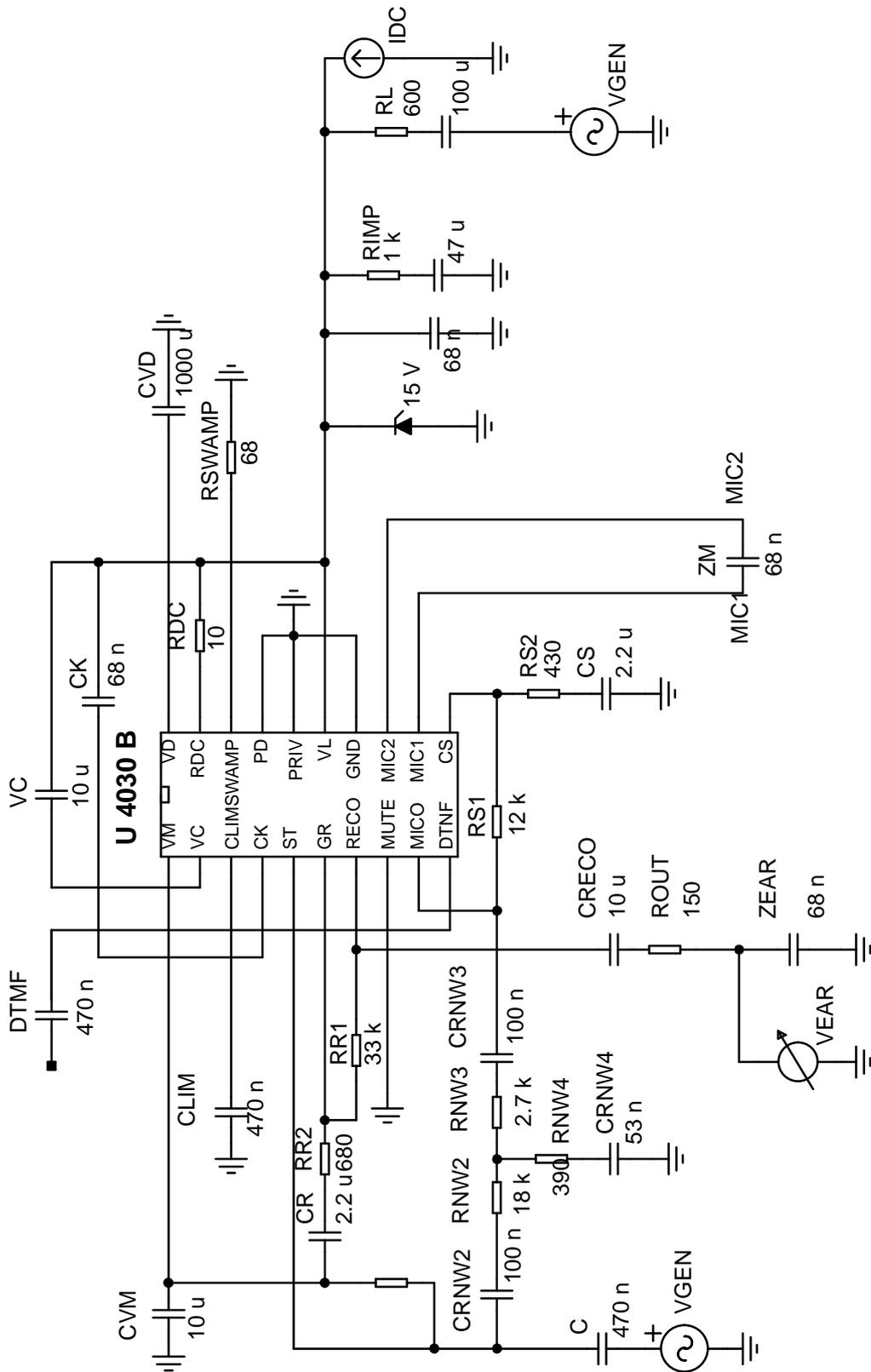
Figure 11.  Receiving gain and sidetone amplification

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Figure 12.  DTMF gain

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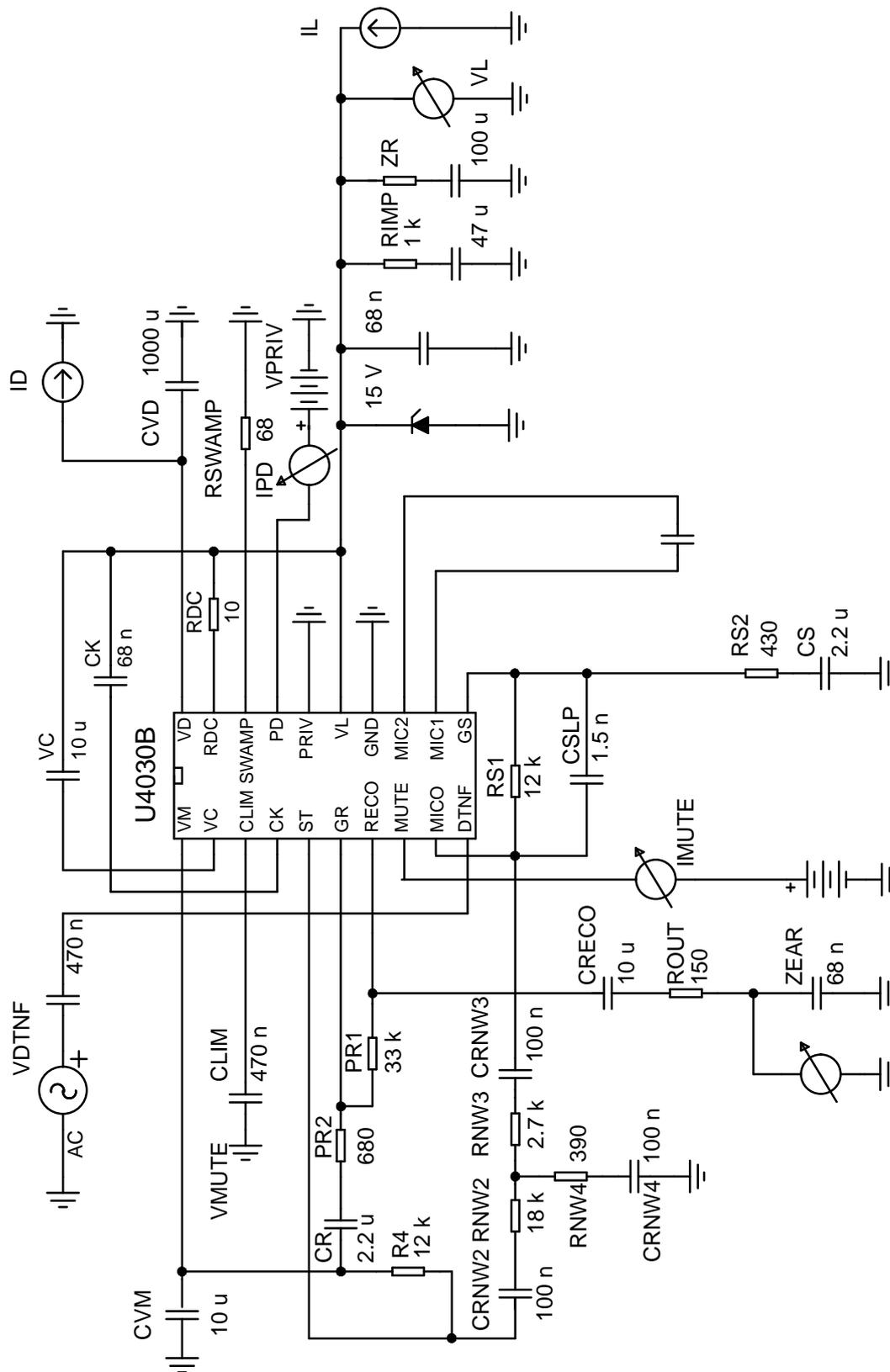
Preliminary Information
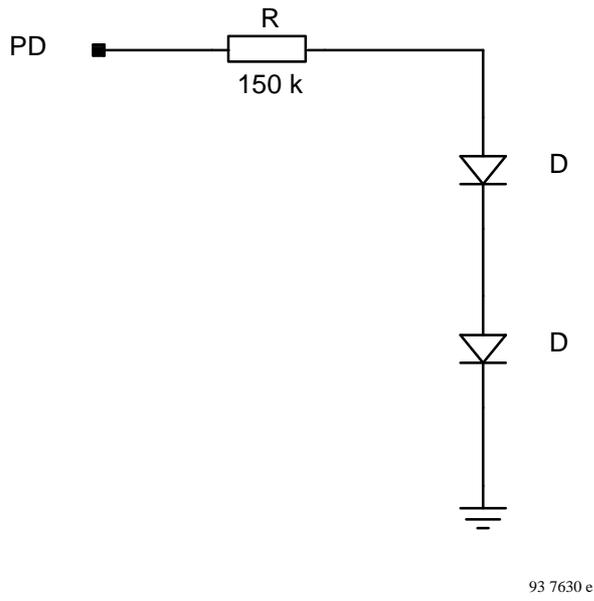
Figure 13. PD input
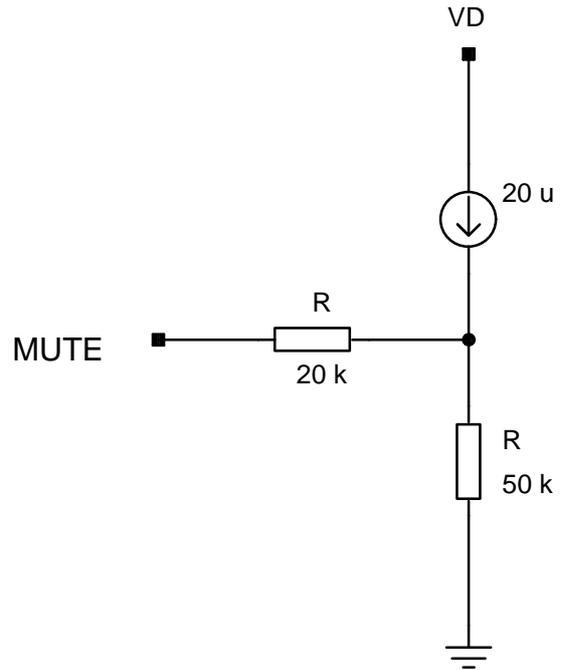


Figure 14. Mute input

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## Dimensions in mm

Package: DIP20



Package: SO20

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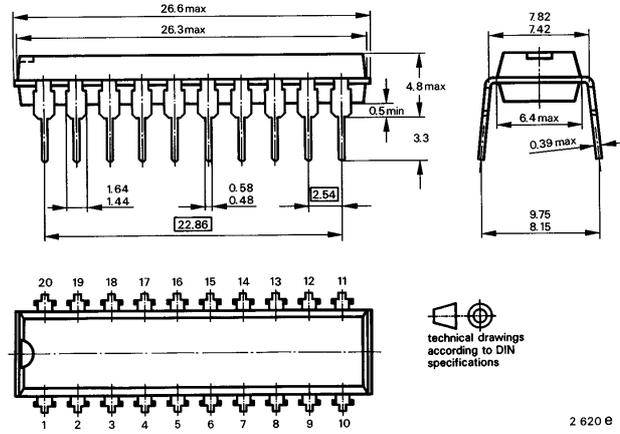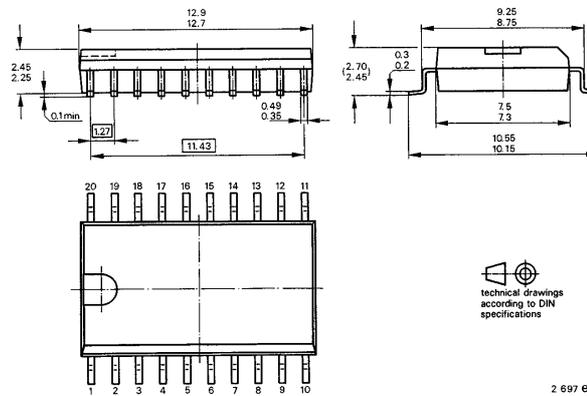
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It is the policy of **TEMIC TELEFUNKEN microelectronic GmbH** to

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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