

Standard Speech Circuit (SSC)

PSB 4500
PSB 4501

Preliminary Data

Bipolar IC

Type	Ordering Code	Package
PSB 4500-P	Q67000-A8146	P-DIP-20
PSB 4500-T	Q67000-A8147	P-DSO-20 (SMD)
PSB 4501-P	Q67000-A8148	P-DIP 20
PSB 4501-T	Q67000-A8149	P-DSO-20 (SMD)

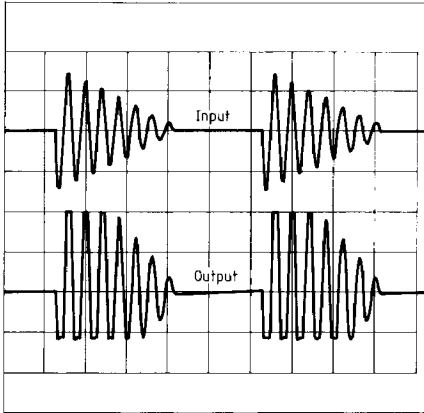
The bipolar PSB 4500/4501 performs speech and interface functions required for electronic telephone sets. It performs electronic switching between dialing and speech. The IC can be operated at a minimum line voltage of 1.6 V DC to permit simultaneous use of several telephone sets. A special anticlipping control circuit prevents line distortion in the transmit direction, which may occur with large microphone signals.

Features

- Operation down to a dc line voltage of 1.6 V (excluding polarity guard)
- Anticlipping control circuit prevents signal distortion on the line in the transmit direction caused by large microphone signals or poor supply and load conditions
- Adjustable voltage regulator for line voltage drop
- Adjustable differential DC resistance
- Current supply for external components
- Input for DTMF signals with confidence tone
- Symmetrical high-impedance inputs (68 k Ω) for dynamic, magnetic and piezoelectric microphones
- Asymmetrical high-impedance input (34 k Ω) for electret microphones
- Wide setting range for microphone and earpiece amplifiers
- Receiving amplifier for magnetic, dynamic and piezoelectric earpieces
- Line loss compensation depending on line current
- Adaptable gain control
- MUTE input for DTMF dialing
- Power down input for pulse dialing or register recall
- Line loss compensation switchable from 3 dB to 6 dB (only for PSB 4500)
- Special microphone MUTE input (only for PSB 4501)
- Fulfills the high German PTT noise requirements

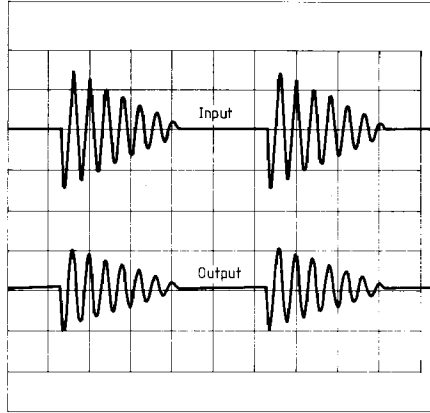
Anticlipping Control Function

Clipping



The diagram shows an input signal which generates a distorted output signal with conventional speech circuits.

Anticlipping



The PSB 4500/4501 processes controlled amplification so that a distortion-free signal with all harmonics is available at the output, having the same dynamic range like the input signal.

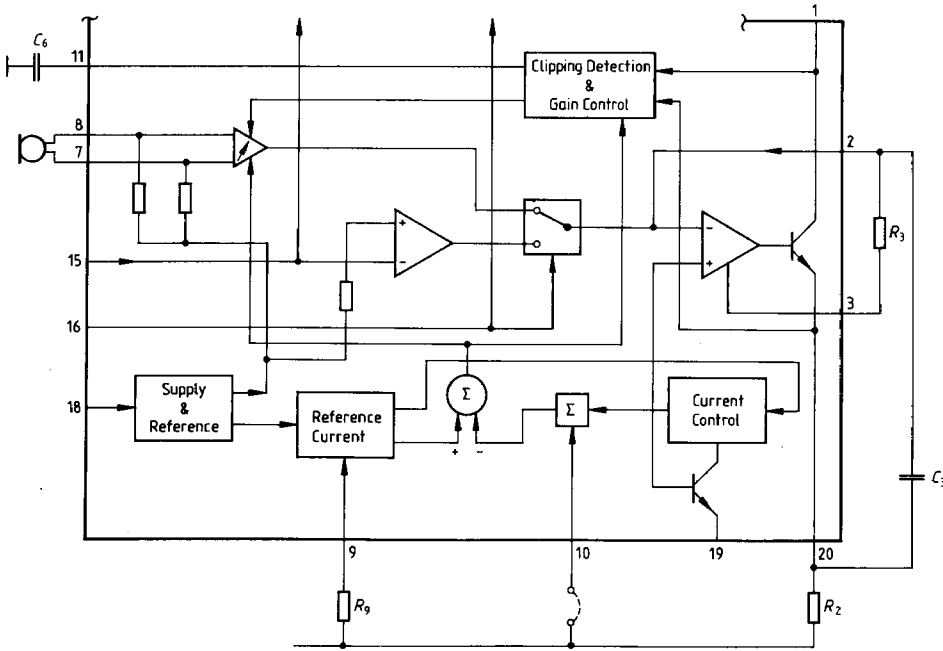
When does the Anticlipping Control Affects?

In poor feeding conditions, e.g.

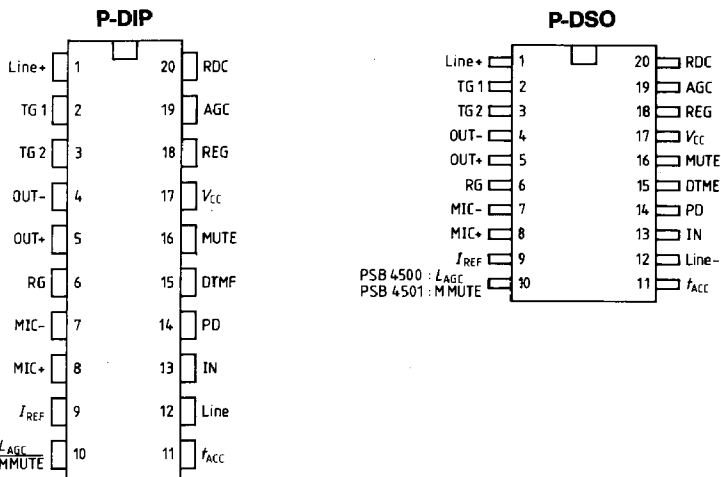
- very low line current and long line cable, or
- two or more telephone sets in parallel operation and a long line cable,
- and high microphone level.

The anticlipping control prevents the transmitted signal from being distorted when the signal is reaching the maximum linear range of the output stage. If any distortion (clipping) is sensed by the peak detector, the gain of the microphone amplifier is reduced at once within a very short time constant to a non-distorting gain level – the PSB 4500/4501 remains in a reduced gain state. Without any loss, the output dynamic range is then equivalent to the input dynamic range. For a capacitor of $C_6 = 470 \text{ nF}$ the release time is approximately 6 ms for each 3 dB overdrive.

Anticlipping Control Circuit



Pin Configurations
(top view)



Pin Definitions and Functions

Pin No.	Symbol	Function
1	Line +	Positive line terminal
2	TG1	Transmitter gain adjustment
3	TG2	Transmitter gain adjustment
4	OUT -	Inverting output, receiving amplifier
5	OUT +	Non-inverting output, receiving amplifier
6	RG	Receiver gain adjustment
7	MIC -	Inverting microphone input
8	MIC +	Non-inverting microphone input
9	I_{REF}	Reference current
10	L_{AGC} MMUTE	Adjustment of AGC-level (PSB 4500) Microphone MUTE (PSB 4501)
11	t_{ACC}	Delay time const. of ACC
12	Line	Negative line terminal
13	IN	Receiving amplifier input
14	PD	Power-down input
15	DTMF	Dual-tone multi-frequency input
16	MUTE	MUTE input
17	V_{CC}	Positive supply decoupling
18	REG	Voltage regulator decoupling
19	AGC	Automatic gain control input
20	RDC	Slope (dc. resistance) adjustment

Figure 1
Block Diagram PSB 4500

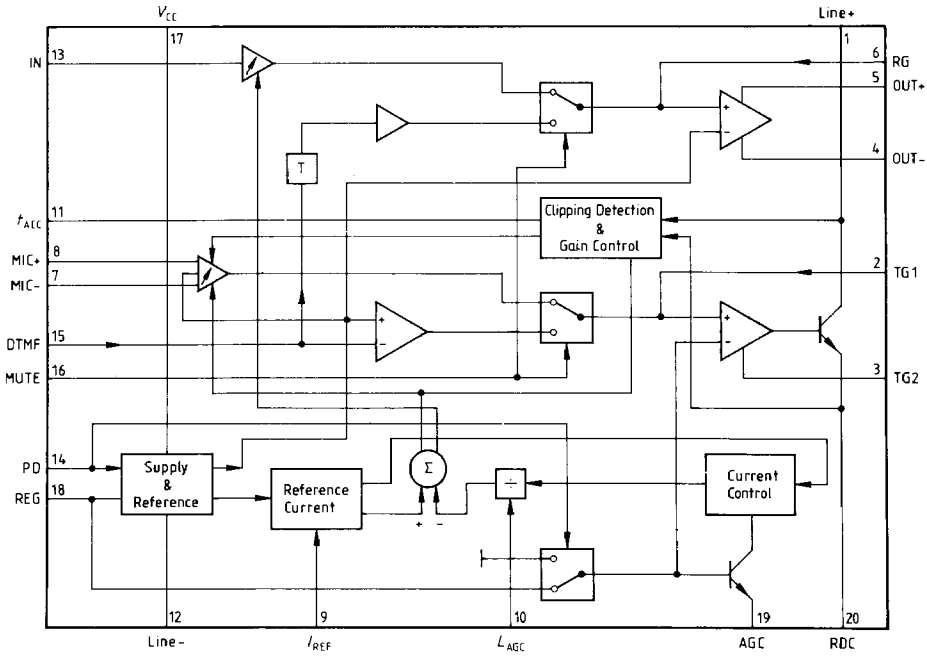
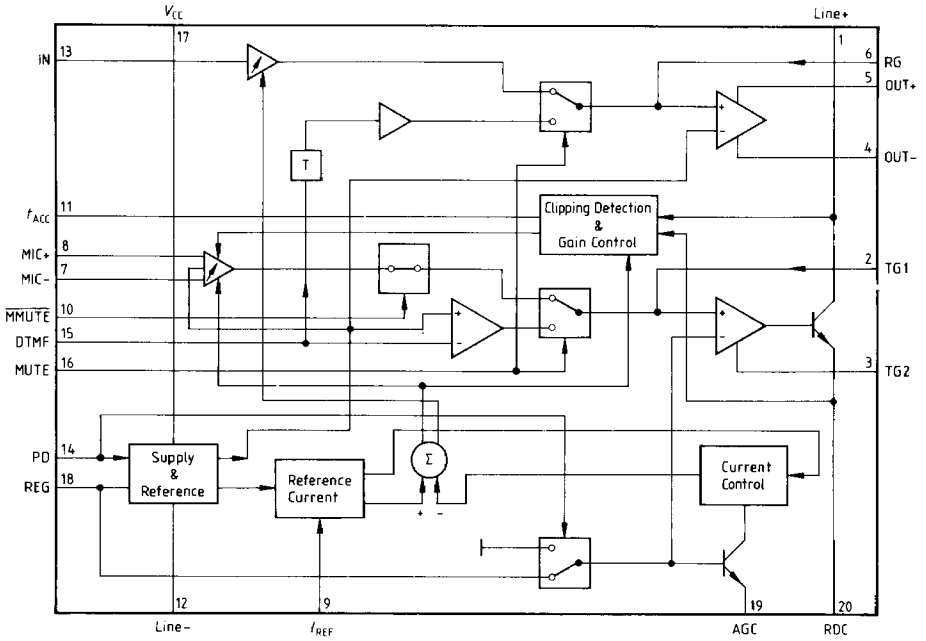


Figure 2
Block Diagram PSB 4501



Circuit Description

V_{CC} (17), Line + (1), RDC (20), I_{REF} (9): DC Supply and Corresponding Control Pins

The IC and its external circuitry are usually supplied from the telephone line. The PSB 4500/4501 generates its own supply voltage at V_{CC} and regulates its voltage drop. External circuitry such as dialing components and microcontrollers are also supplied by V_{CC} .

A smoothing capacitor between V_{CC} and Line – is used to decouple the ac voltage of the supply. Another capacitor between REG and Line – decouples the internal voltage regulator. The internal reference current is adjusted by a resistor (3.6 k Ω) between I_{REF} and Line –.

The DC current flowing into the circuit is determined by the exchange supply voltage V_{Exch} , the feeding bridge resistance R_{Exch} , the subscriber line DC resistance R_{Line} and the DC voltage at the telephone set (see figure 3).

If the line current I_{Line} exceeds the current $I_{CC} + I_p + 0.5$ mA required by the IC and its peripherals ($I_{CC} \approx 1$ mA), the voltage regulator diverts the excess current via Line +.

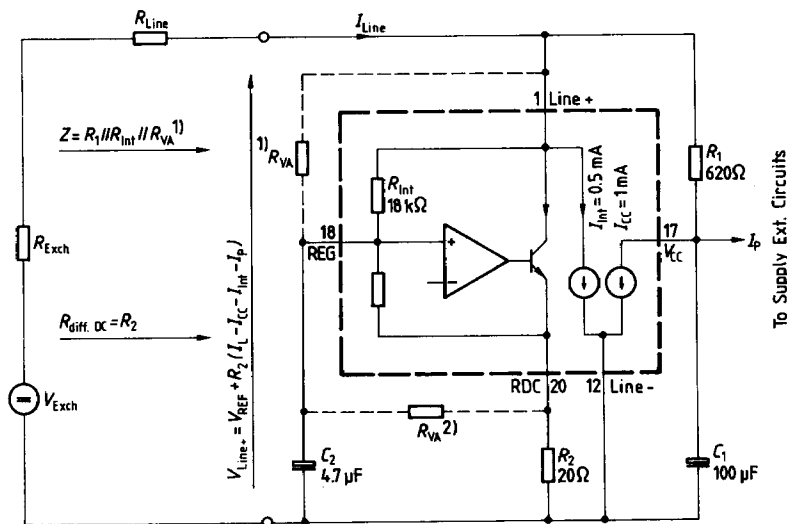
The voltage regulator adjusts the mean voltage to

$$V_{Line} = V_{REF} + I_{RDC} \times R_2 = V_{REF} + (I_{Line} - I_{CC} - 0.5 \times 10^{-3} - I_p) \times R_2.$$

V_{REF} is the temperature compensated voltage of 3.6 V, between Line + and RDC. R_2 is an external resistor between RDC and Line – with a preferred value of 20 Ω . Changing R_2 influences the microphone gain, DTMF gain, the current dependent gain control characteristics, side tone, the max. output swing at Line + and the DC characteristic (particularly with low voltages).

With $I_{RDC} \gg I_{CC} + 0.5$ mA + I_p , the static behavior of the IC is similar to a 3.6 V voltage regulator diode with an internal resistance R_2 . In the audio frequency range the dynamic impedance equals R_1 , since R_{int} or $R_{VA} \gg R_1$. R_{VA} is an external resistor, by means of which the internal reference voltage can be adjusted. If R_{VA} is connected between pins Line + (1) and REG (18), the reference voltage V_{REF} is reduced. If R_{VA} is connected between pins REG (18) and RDC (20), the reference voltage V_{REF} is increased. The corresponding equivalent circuit diagram is shown in figure 3.

Figure 3



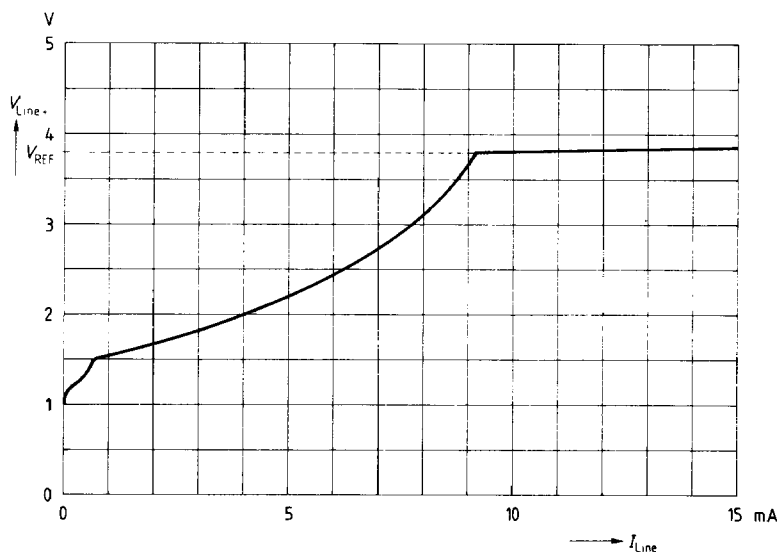
Equivalent dc and impedance circuit of PSB 4500/4501

- Note**
- 1) R_{VA} connected between pin 18-1 reduces the DC voltage drop across the circuit.
 $V_{REF} = 1.3 \text{ V} + (R_{VA(1-18)} \parallel 16.3 \text{ k}\Omega) \times 0.14 \text{ mA}$
 - 2) R_{VA} connected between pin 18-20 increases the DC voltage drop across the circuit.
 $V_{REF} = 2.93 \text{ V} + 21200 \text{ V}\Omega / (R_{VA(18-20)} \parallel 31.6 \text{ k}\Omega)$

The current available from V_{CC} to supply external circuitry depends on the external components and on the line current. **Figure 8** shows this current for $V_{CC} > 2.2 \text{ V}$ (min). With the MUTE input in the LOW state and the receiving amplifier in operation, the supply current available for peripherals is further decreased.

If the current on the telephone line falls below 9 mA, the reference voltage is automatically adjusted to a lower value (typ. 1.6 V at 1 mA) (see **figure 4**). This enables several sets to be operated in parallel down to a minimum DC line voltage of 1.6 V (excluding polarity guard) with slightly reduced performance. At line currents lower than 9 mA the circuit operates with limited transmit and receive levels.

Figure 4
Typical DC Characteristics of PSB 4500/PSB 4501



MIC+ (8), MIC- (7), TG1 (2), TG2 (3): Microphone Inputs and Gain Adjustment

The PSB 4500/4501 has symmetrical microphone inputs. The input impedance is $68\text{ k}\Omega$ ($2 \times 34\text{ k}\Omega$) and the voltage gain typically amounts to 52 dB for the application given in **figure 15a/b**. Either dynamic, magnetic, piezoelectric or electret microphones with integrated FET source follower can be used.

Figure 13 shows the IC in configuration with the above mentioned microphones. The microphone amplifier can be adjusted to a gain between 44 dB and 52 dB, depending on the sensitivity of the transducer used. The amplification is proportional to the value of the external resistor R_3 , which is connected between TG1 and TG2. Amplification over 52 dB is also possible (up to 60 dB), then, however, the DC voltage is subject to wider spread and the minimum voltage at 11 mA ($V_{Line} = 3.55\text{ V}$) cannot be ensured. For reasons of stability, an external capacitor C_3 with 100 pF has to be connected between TG1 and RDC. A larger value can be selected to obtain a low-pass filter. The cut-off frequency is determined by the time constant $R_3 \times C_3$.

Side-Tone Suppression

An anti-side-tone network consisting of R_1 , Z_{Line} , R_2 , R_5 , R_6 , R_7 and Z_{Bal} (see figure 15a/b) suppresses the transmitted signal in the earpiece. The following conditions have to be fulfilled to achieve maximum compensation:

$$R_6/R_5 = R_2/R_1 \quad (1)$$

$$Z_{Bal} = (R_7/R_1) Z_{Line} \quad (2)$$

Fixed values must be chosen for R_1 , R_2 , R_5 and R_6 to fulfill condition (1), provided that

$$R_2 \ll |R_7 + Z_{Bal}| \quad (3)$$

$$R_7 \parallel Z_{Bal} \ll R_6 \quad (4)$$

and with (2) in (4)

$$R_6 \gg R_7 \times (Z_{Line}/(R_1 + Z_{Line})) \quad (5)$$

The value of Z_{Bal} has to correspond to a standard capacitor of the E6 or E12 series.

In practice Z_{Line} varies strongly with line length and cable type, therefore a mean value should be selected for Z_{Bal} . The side-tone suppression also depends on how well $Z_{Bal}/(R_7/R_1)$ equals the mean line impedance.

The anti-sidetone network (see figure 15a/b) attenuates the signal from the line by 32 dB. Attenuation over the audio frequency rang is nearly linear.

The conventional Wheatstone bridge can be used as an alternative to the above described special bridge. Both bridges may be used with a resistive or a complex impedances.

$t_{ACC}(11)$: Anti-Clipping Control (ACC)

In poor feeding conditions, e.g.

- very low line current and long line cable or
- two or more telephone sets in parallel operation and a long line cable
- and high microphone level

The anticlipping control prevents the transmitted signal from being distorted when the signal is reaching the maximum linear range of the output stage. If any distortion (clipping) desensed by the peak detector (threshold level), the gain of the microphone amplifier is reduced at once within a very short time constant to a non-distorting gain level – the PSB 4500/4501 remains in a reduced gain state. Without any loss, the output dynamic range is then equivalent to the input dynamic range. How long the circuit remains in this reduced transmitting condition, is dependent on the overdrive condition. For a capacitor of $C_6 = 470$ nF the release time is approximately 6 ms for each 3 dB overdrive, respectively for each 3 dB gain reduction. This release time is proportional to the value of C_6 at pin 11 (t_{ACC}), because it will be recharged by an internal current source.

MUTE (16): MUTE Input

A HIGH level enables the DTMF input and inhibits the microphone and receiving amplifier inputs.

With LOW level or open circuit the same occurs vice versa.

Switching the MUTE input causes negligible clicking in the earpiece and line. When V_{CC} drops below 2 V, the IC is always in the speech condition, independent of the dc level applied to the MUTE input.

MMUTE (10) (PSB 4501 only): Microphone MUTE Input

A LOW level at the MMUTE pin (or connection to GND/Line -) inhibits the microphone input, but has no influence on the receiving amplifier, the received signal can be heard normally in the earpiece.

HIGH level or open MMUTE pin provides the normal function in the transmit direction.

When V_{CC} drops below 2 V, the MMUTE-attenuation will be reduced.

DTMF (15): DTMF Input

When the DTMF input is enabled, dialing signals can be transmitted on the telephone line. The voltage amplification from pin DTMF to pin Line + is typ. 26 dB and varies with R_3 as well as with the microphone amplification. The dialing signals can be faintly heard in the earpiece (confidence tone).

IN (13), OUT+ (5), OUT- (4), RG (6): Receive Amplifier Input and Outputs, Amplifier Adjustment

The receive amplifier has one input IN and two complementary outputs OUT+ (non-inverting) and OUT- (inverting). Both outputs may be operated in symmetrical or asymmetrical mode, depending on the sensitivity and type of the earpiece (**see figure 14**). Amplification from IN to OUT+ is typ. 31 dB. This is sufficient for magnetic or dynamic earpieces of low impedance. These earpieces are suitable for asymmetrical operation. Using both outputs enables differential drive, and amplification is increased by 6 dB. Differential drive should be chosen if the earpiece impedance exceeds 450 Ω (high-impedance dynamic, magnetic or piezoelectric earpieces).

The maximum output voltage of the receiving amplifier depends on the voltage at V_{CC} . The max. output voltage in speech condition is higher than during continuous wave drive, since with continuous wave drive V_{CC} is lower due to the increased current consumption of the output stage than in speech condition with varying amplitude.

The receiving amplification for asymmetrical mode can be adjusted between 20 dB and 39 dB. For symmetrical mode the adjustment range is between 26 dB and 45 dB to permit the use of less sensitive transducers. Two external capacitors $C_4 = 100$ pF and $C_7 = 10 \times C_4 = 1$ nF are required to ensure stability. A first-order low-pass filter is obtained with a larger value of C_4 . The cut-off frequency is determined by the time constant $R_4 \times C_4$.

AGC (19), L_{AGC} (10), (L_{AGC} only for PSB 4500): Automatic Gain Control Input

Connecting a resistor R_g between AGC and Line – enables automatic line loss compensation (current dependent AGC). The automatic gain control varies microphone and receive gain according to the dc line current. For the PSB 4500 the control range can be switched from 3 dB to 6 dB by connecting pin 10 (L_{AGC}) to ground. For 3 dB control range this pin should be left open. The PSB 4501 has a fixed 6 dB control range. Switching affects only the slope of the attenuation dependent on the line current; it has no influence on the AGC threshold. A control range of 6 dB corresponds to a line length of 5 km for a twisted cooper pair cable of 0.5 mm diameter, a dc resistance of 176 Ω /km and an average attenuation of 1.2 dB/km.

Resistor R_g should be chosen with regard to the exchange supply voltage and its feeding bridge resistance (see figure 9 and table 1). The start end of the AGC range depends on the line current, its ratio does not depend on R_g . If AGC is not required, the AGC inputs should not be connected. In this case microphone and receive amplifiers are operated at maximum gain.

PD (14): Power-Down Input

During pulse dialing or register recall the line is interrupted, consequently the speech circuit and external components are not supplied from the line during this period. These gaps have to be bridged by the charge stored in the smoothing capacitor C_1 . Applying HIGH level to the PD input reduces the supply current required by the IC from 1.1 mA to typ. 55 μ A. This reduces also the required value of the capacitor C_1 needed to supply the circuit during line interruption.

In addition, a HIGH level at PD disconnects capacitor C_2 at REG from the IC, with the result that the voltage stabilizer has no switch-on delay. As a consequence, the IC has no influence on the current waveform during pulse dialing or register recall.

If the power down function is not required, the PD pin may be left unconnected.

Absolute Maximum Ratings

Limiting values in accordance with the absolute maximum system (IEC 134)

Parameter	Symbol	Limit Values		Unit
		min.	max.	
Positive line voltage (continuous)	V_{Line}		12	V
Repetitive line voltage during switch-on or line interruption	V_{Line}		13.2	V
Repetitive peak line voltage $t_p/p = 1 \text{ ms}/5 \text{ s}$; $R_{10} = 13 \Omega$ $R_2 = 20 \Omega$ (see figure 15a, b)	V_{Line}		28	V
Line current	I_{Line}		140	mA
Voltage on all other pins	V_i $-V_i$		$V_{CC}+0.7$ 0.7	V V
Total power dissipation	P_{tot}		640	mW
Storage temperature range	T_{stg}	-40	125	°C
Operating ambient temperature range	T_A	-25	75	°C

The maximum ratings may not be exceeded under any circumstances, not even momentarily or individually, as permanent damage to the IC will result.

AC/DC Characteristics

$I_{Line} = 11$ to 140 mA; $V_{Line-} = 0$ V, $f = 800$ Hz; $T_A = 25^\circ\text{C}$; unless otherwise specified

Parameter	Symbol	Limit Values			Unit
		min.	typ.	max.	

Supply: Line+ and V_{CC} (pins 1 and 17)

Voltage drop over circuit; between pin 1 and pin 12 = V_{Line} ; microphone inputs open

I_{Line}	V_{Line}		1.6		V
$I_{Line} = 4$ mA	V_{Line}	1.75	2.0	2.25	V
$I_{Line} = 7$ mA	V_{Line}	2.25	2.8	3.35	V
$I_{Line} = 11$ mA	V_{Line}	3.55	3.8	4.05	V
$I_{Line} = 15$ mA	V_{Line}	3.65	3.9	4.15	V
$I_{Line} = 100$ mA	V_{Line}	4.9	5.6	6.5	V
$I_{Line} = 140$ mA	V_{Line}			7.5	V

Variation with temperature

$I_L = 15$ mA	$\Delta V_{Line}/\Delta T$	-3	-1	1	mV/K
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Voltage drop over circuit with external resistor R_{VA} ;

$I_{Line} = 15$ mA	V_{Line}	3.1	3.4	3.7	V
R_{VA} (pin 1 to pin 18) = 68 k Ω	V_{Line}	4.2	4.5	4.8	V
R_{VA} (pin 18 to pin 20) = 39 k Ω					

Supply current I_{CC} ; current into pin 17

PD = LOW (pin 14); $V_{CC} = 2.8$ V	I_{CC}		1.1	1.45	mA
PD = HIGH (pin 14); $V_{CC} = 2.8$ V	I_{CC}		55	82	μA

Current available from pin 17 to supply peripheral circuits;

$I_{Line} = 15$ mA; $V_{CC} \geq 2.2$ V; MUTE = HIGH	I_D	1.3	1.7		mA
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Microphone Inputs MIC+ and MIC- (pins 7 and 8)

Input impedance					
Differential (between pins 7 and 8)	$ Z_{is} $	54.5	68	82	k Ω
Single ended (pin 7 or w.r.t. Line-)	$ Z_{is} $	27	34	41	k Ω
Common-mode rejection ratio	k_{CMR}		82		dB
Voltage amplification (from pin 7-8 to pin 1); $I_{Line} = 15$ mA; $R_3 = 68$ k Ω	A_{vd}	51	52	53	dB
Variation with frequency $f = 300$ Hz to 3400 Hz	$\Delta A_{vd}/\Delta f$	-0.5	± 0.2	0.5	dB
Variation with temperature $I_{Line} = 50$ mA; $T_A = -25$ to 75°C	$\Delta A_{vd}/\Delta T$		t.b.n.		dB

AC/DC Characteristics

$I_{\text{Line}} = 11$ to 140 mA; $V_{\text{Line-}} = 0$ V, $f = 800$ Hz; $T_A = 25^\circ\text{C}$; unless otherwise specified

Parameter	Symbol	Limit Values			Unit
		min.	typ.	max.	

Dual-Tone Multi-Frequency Input DTMF (pin 15)

Input impedance	$ Z_{\text{is}} $	16.5	20.7	25	k Ω
Voltage amplification (from pin 15 to pin 1); $I_{\text{Line}} = 15$ mA; $R_3 = 58$ k Ω	A_{vd}	25	26	27	dB
Variations with frequency $f = 300$ Hz to 3400 Hz	$\Delta A_{\text{vd}}/\Delta f$	-0.5	± 0.2	0.5	dB
Variation with temperature $I_{\text{Line}} = 50$ mA; $T_A = -25$ to 75°C	$\Delta A_{\text{vd}}/\Delta T$		± 0.2		dB
Transmitting gain TG1 and TG2 (pins 2 and 3) Amplification variation with R_3 (connected between pins 2 and 3), transmitter amplifier	ΔA_{vd}	-8		0	dB

Transmitting Amplifier Output Line+ (pin 1) (figure 6a, b)

Output Voltage at $I_{\text{Line}} = 15$ mA; $R_3 = 68$ k Ω

Threshold level; $d_{\text{tot}} \leq 2\%$ (see also figure 11)	$V_{\text{Line(rms)}}$		1.5		V
Distortion at 10 dB overdrive	d_{tot}			5	%
Distortion at 15 dB overdrive	d_{tot}			10	%
Threshold level ($R_3 = 68$ k Ω) $I_{\text{Line}} = 7$ mA; $d_{\text{tot}} \leq 2\%$ $I_{\text{Line}} = 4$ mA; $d_{\text{tot}} \leq 2\%$	$V_{\text{Line(rms)}}$ $V_{\text{Line(rms)}}$		0.9 0.45		V V
Attack time for ACC; $C_6 = 470$ nF	t_{att}			5	ms
Release time for each 3 dB overdrive; $C_6 = 470$ nF	t_{rel}		6		ms
Noise output voltage $I_{\text{Line}} = 15$ mA; $R_3 = 68$ k Ω ; 200Ω between pins 7 and 8; psophometrically weighted (P53 curve)	$V_{\text{no(rms)}}$		-72		dBmp

AC/DC Characteristics

$I_{Line} = 11$ to 140 mA; $V_{Line-} = 0$ V, $f = 800$ Hz; $T_A = 25$ °C; unless otherwise specified

Parameter	Symbol	Line Values			Unit
		min.	typ.	max.	

Receiving Amplifier Input IN (pin 13)

Input impedance	$ Z_{is} $	16.8	21	25.2	k Ω
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Receiving Amplifier Outputs OUT+ and OUT- (pins 5 and 4)

Output impedance; single-ended	$ Z_{os} $		4		Ω
Voltage amplification from pin 13 to pin 4-5 $I_{Line} = 15$ mA; $R_4 = 100$ k Ω single ended; $R_L = 300$ Ω (from pin 13 to pin 4-5) differential; $R_L = 600$ Ω (from pin 13 to pins 4-5)	A_{vd}	30	31	32	dB
	A_{vd}	36	37	38	dB
Variation with frequency, $f = 300$ Hz to 3400 Hz	$\Delta A_{vd}/\Delta f$	-0.5	± 0.2	0.5	dB
Variation with temperature $I_{Line} = 50$ mA; $T_A = -25$ to 75 °C	$\Delta A_{vd}/\Delta T$		± 0.2		dB
Output voltage at $I_p = 0$; $d_{tot} = 2\%$; sine-wave drive; $R_4 = 100$ k Ω single-ended; $R_L = 150$ Ω differential; $R_L = 450$ Ω differential; $C_L = 47$ nF (100 Ω series resistor); $f = 3400$	$V_{o(rms)}$	0.25	0.29		V
	$V_{o(rms)}$	0.45	0.55		V
	$V_{o(rms)}$	0.65	0.80		V
Output voltage at $I_p = 0$; $d_{tot} = 10\%$; sine-wave drive; $R_4 = 100$ k Ω ; $R_L = 150$ Ω $I_{Line} = 4$ mA $I_{Line} = 7$ mA	$V_{o(rms)}$		15		mV
			130		mV
Noise input voltage $I_{Line} = 15$ mA; $R_4 = 100$ k Ω ; pin 13 open psophometrically weighted (P53 curve) single-ended; $R_L = 300$ Ω differential; $R_L = 600$ Ω	$V_{o(rms)}$		50		μ V
	$V_{o(rms)}$		100		μ V
Receiving Gain RG (pin 6)					
Amplification variation with R_4 (connected between pins 6 and 5), receiving amplifier	ΔA_{vd}	-11		8	dB

AC/DC Characteristics

$I_{Line} = 11$ to 140 mA; $V_{Line-} = 0$ V, $f = 800$ Hz; $T_A = 25^\circ\text{C}$; unless otherwise specified

Parameter	Symbol	Limit Values			Unit
		min.	typ.	max.	

MUTE Input (pin 16)

Input voltage HIGH LOW	V_{IH} V_{IL}	1.5		V_{CC} 0.3	V V
Input current	I_{MUTE}		8	15	μA
Reduction of voltage amplification from MIC + (pin 7) and MIC - (pin 8) to Line + (pin 1) MUTE = HIGH	ΔA_{vd}		70		dB
Voltage amplification from DTMF (pin 15) to OUT + (pin 5) or OUT - (pin 4) MUTE = HIGH; single-ended load $R_L = 300 \Omega$	A_{vd}	-21	-19	-17	dB

Power-Down Input PD (pin 14)

Input voltage HIGH LOW	V_{IH} V_{IL}	1.5		V_{CC} 0.3	V V
Input current (into pin 14)	I_{PD}		5	10	μA

MMUTE input (pin 10), only PSB 4501

HIGH LOW	V_{IH} V_{IL}	1.5		V_{CC} 0.3	V V
Input current, $I_{Line} = 15$ mA	$I_{MMUTE L}$ $I_{MMUTE H}$		-5 3		μA μA
Reduction of voltage amplification from MIC + (pin 7) and MIC - (pin 8) to Line + (pin 1) MMUTE = LOW	ΔA_{vd}		70		dB

Automatic Gain Control Input AGC (pin 19)

Controlling the gain from pin 1 to pins 4-5 and the gain from pins 7-8 to pin 1, $R_g = 110$ k Ω (between pins 19 and 12)					
Amplification control range fixed for PSB 4501	A_{vd}		-6		dB
Amplification control range for PSB 4500 with $L_{AGC} = V_{Line-}$ with $L_{AGC} = \text{open}$	A_{vd}		-6 -3		dB dB
Highest line current for maximum amplification	I_{Line}		22		mA
Highest line current for minimum amplification	I_{Line}		60		mA

Figure 6a

PSB 4500: Test Circuit for Defining Voltage Amplification of MIC+ and MIC- and DTMF Inputs

Voltage amplification is defined as: $A_{Vd} = 20 \lg V_o/V_i$. For measuring the amplification from MIC+ and MIC- the MUTE input should be LOW or open, for measuring the DTMF input MUTE should be HIGH. Inputs not under test should be open.

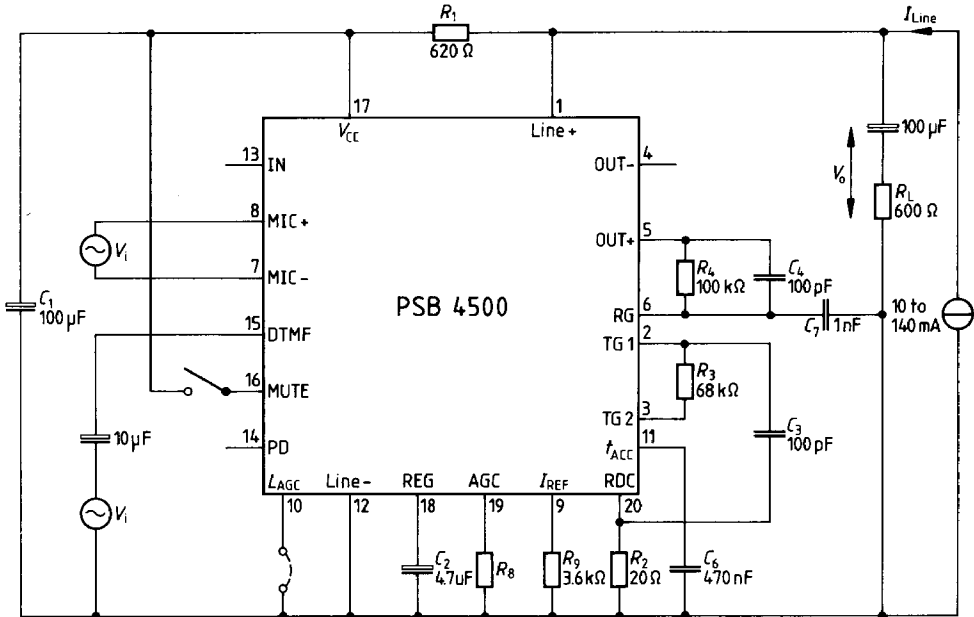


Figure 6a

PSB 4501: Test Circuit for Defining Voltage Amplification of MIC+ and MIC - and DTMF Inputs

Voltage amplification is defined as: $A_{vd} = 20 \log V_o/V_i$. For measuring the amplification from MIC+ and MIC- the MUTE input should be LOW or open and the $\overline{\text{MMUTE}}$ input should be HIGH or open, for measuring the DTMF input MUTE should be HIGH. Inputs not under test should be open.

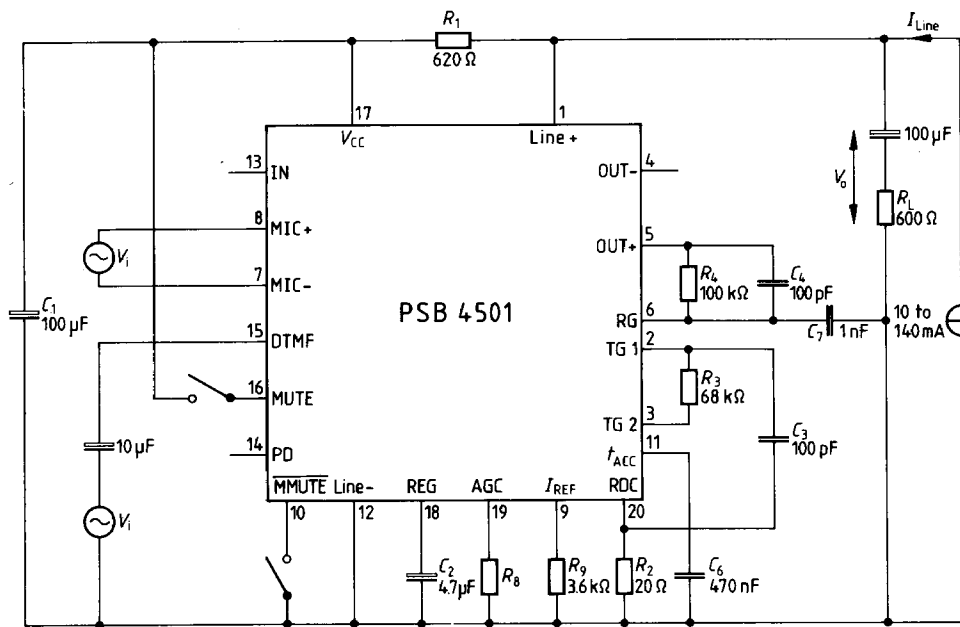


Figure 7a

PSB 4500: Test Circuit for Defining Voltage Amplification of the Receiving Amplifier

Voltage amplification is defined as: $A_{vd} = 20 \log V_O/V_I$.

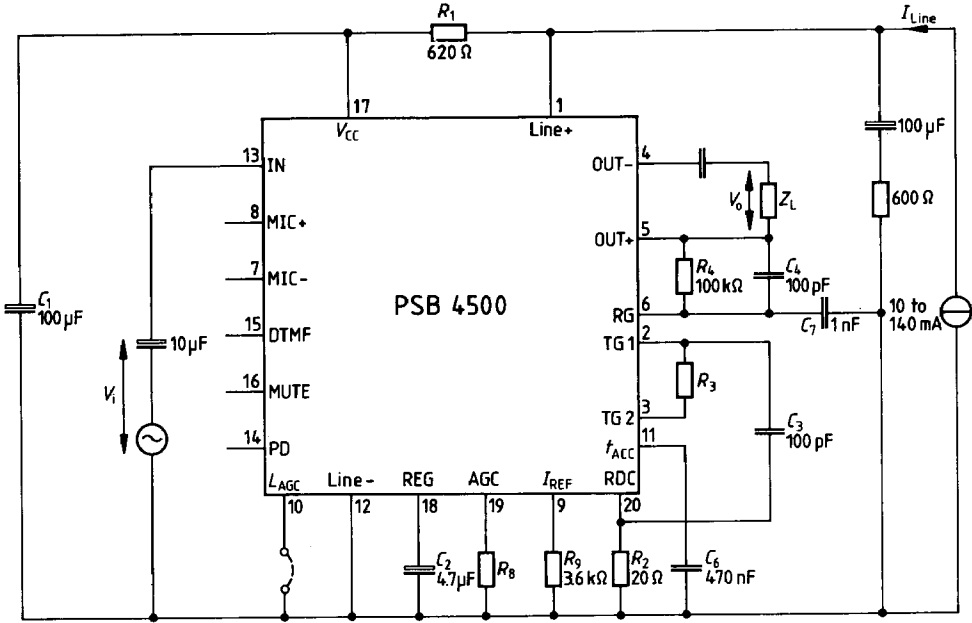


Figure 7b

PSB 4501: Test Circuit for Defining Voltage Amplification of the Receiving Amplifier

Voltage amplification is defined as: $A_{vd} = 20 \log V_O/V_I$.

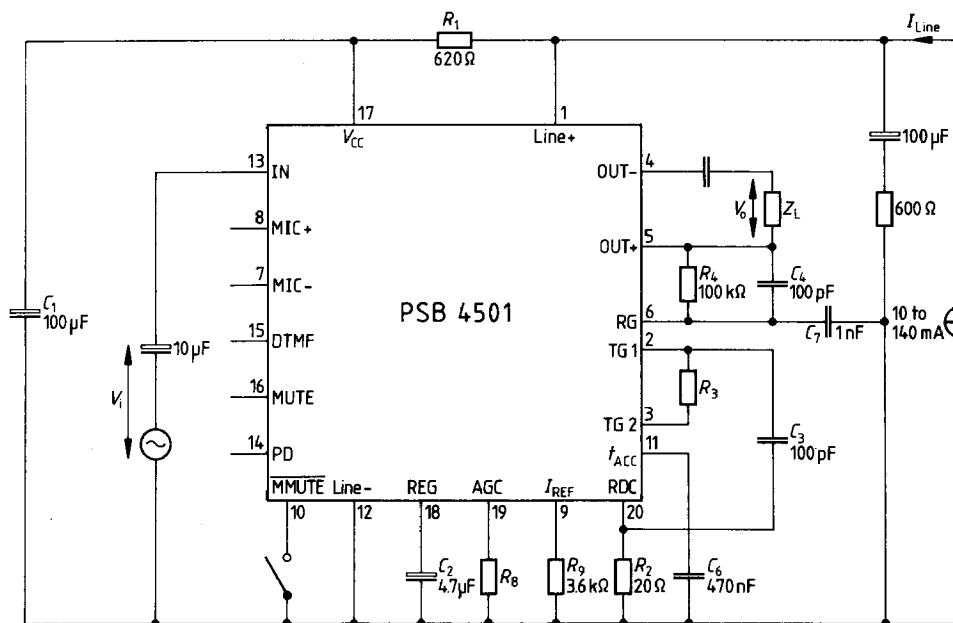


Figure 8

Typical Current I_p Available from V_{CC} for Peripheral Circuitry with Voltage at $V_{CC} \geq 2.2$ V

Curve (a) is valid when the receiving amplifier is not driven or when MUTE = HIGH, curve (b) is valid when MUTE = LOW, \overline{MMUTE} is open and the receiving amplifier is driven; $V_{O(rms)} = 150$ mV, $R_L = 150 \Omega$ asymmetrical.

The supply possibilities can be increased simply by setting the voltage drop over the circuit V_{Line} to a higher value by means of resistor R_{VA} (18-20).

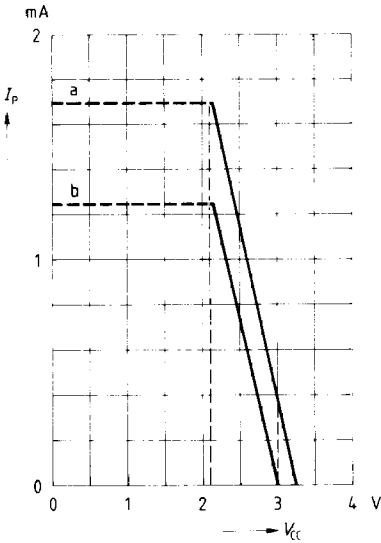


Figure 9

Variation of amplification with line current with R_g as a parameter

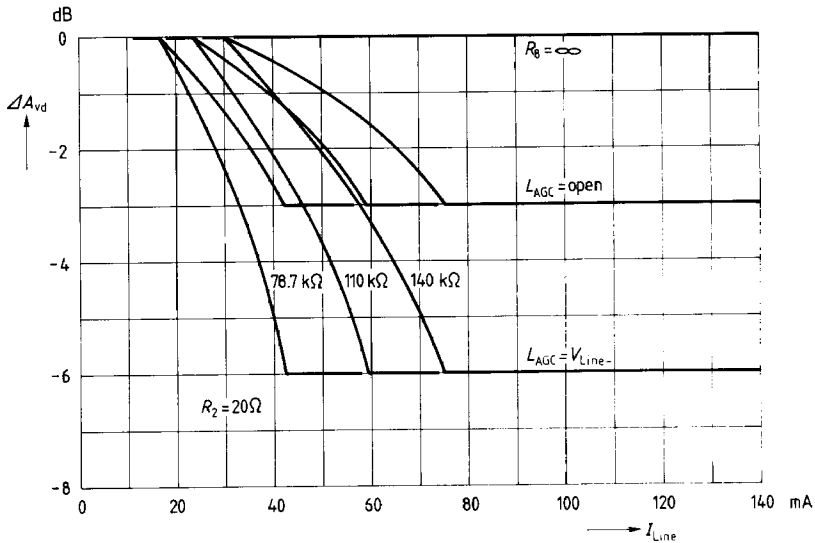


Table 1

Values of resistor R_g for optimum line loss compensation, for various usual values of exchange supply voltage V_{Exch} and exchange feeding bridge resistance R_{Exch}

		$R_{Exch} (\Omega)$			
		400	600	800	1000
		$R_g (k\Omega)$			
V_{Exch} (V)	36	100	78.7	X	X
	48	140	110	93.1	82
	60	X	X	120	102

$R_g = 20 \Omega$

Figure 10

The line output signal of a kHz burst signal on $R_L = 600 \Omega$
at $I_{L_{line}} = 7 \text{ mA}$ by a microphone input level of 2 mV (lin. range)
and an overdrive level of 20 mV (overdrive nearly 20 dB)

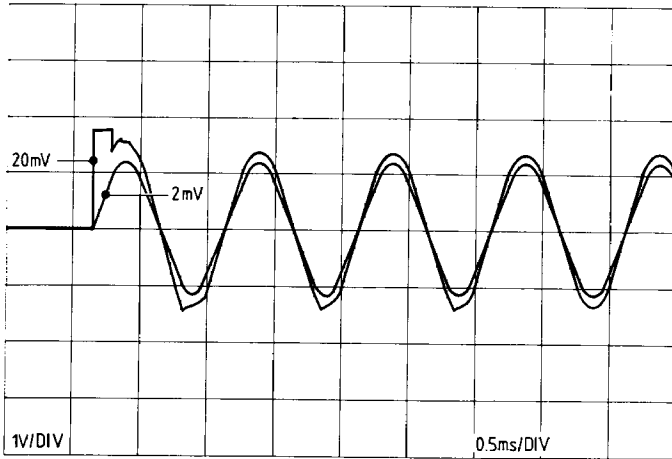


Figure 11

Line voltage $V_{LN(rms)}$ and THD as a function of the microphone input level

The crosspoint of the slope for the linear range with the slope corresponding to the limited output level determines the threshold level. From this point the gain will be reduced – it is in overdrive mode.

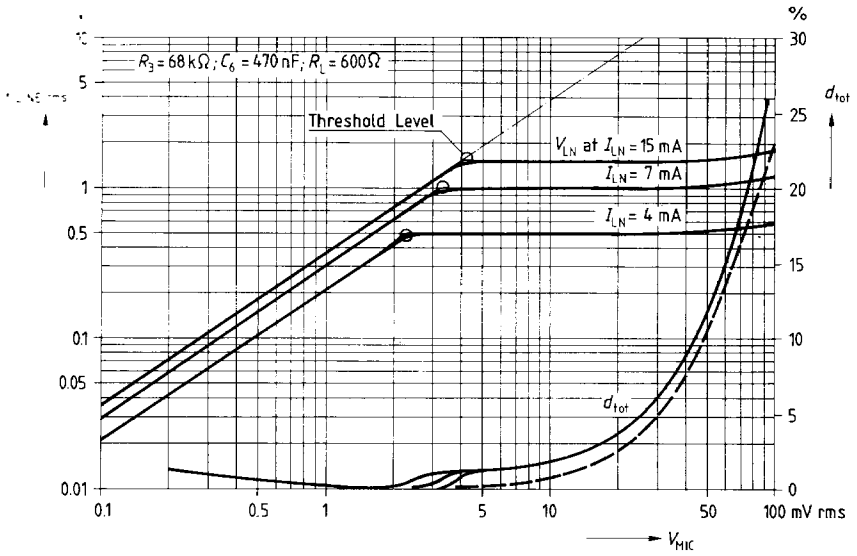
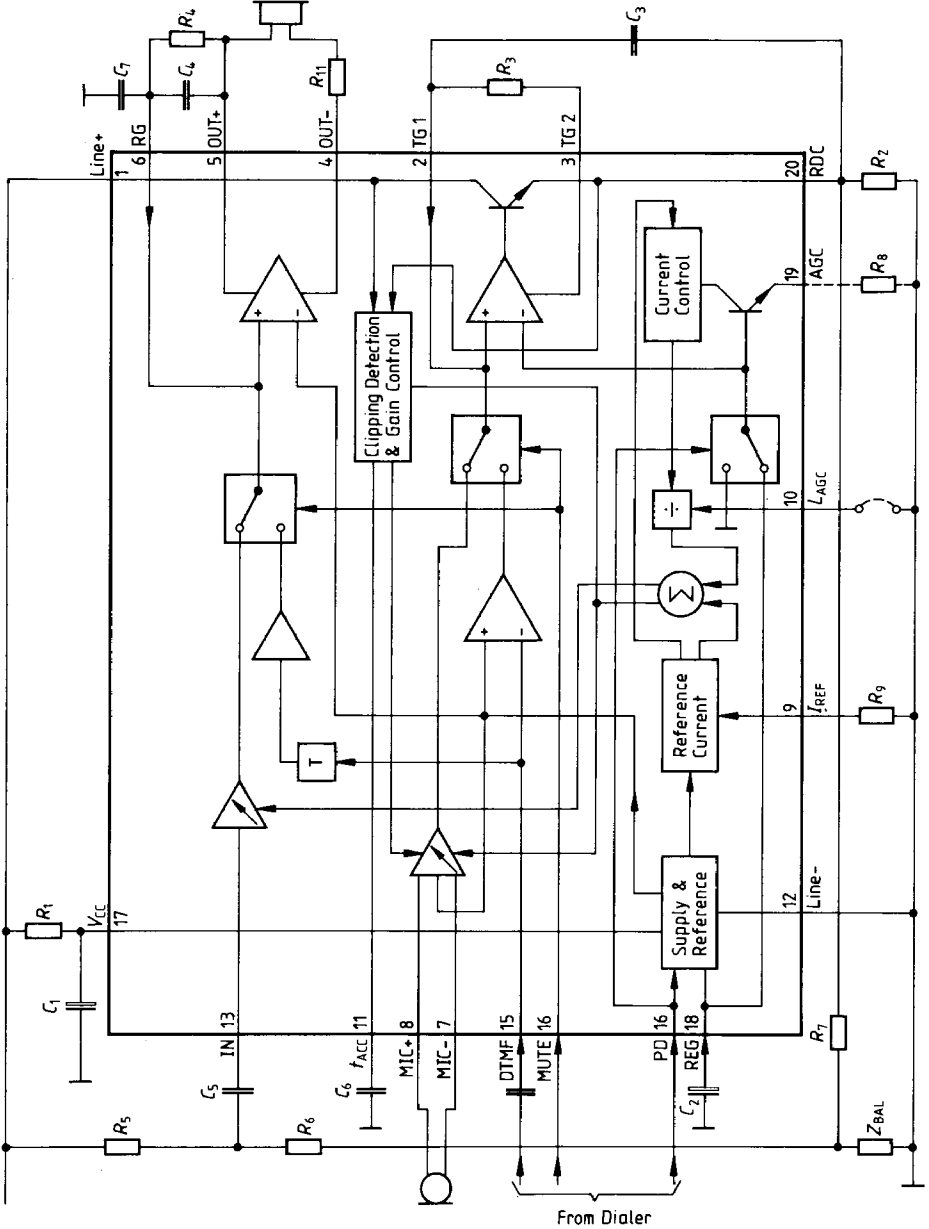


Figure 12a

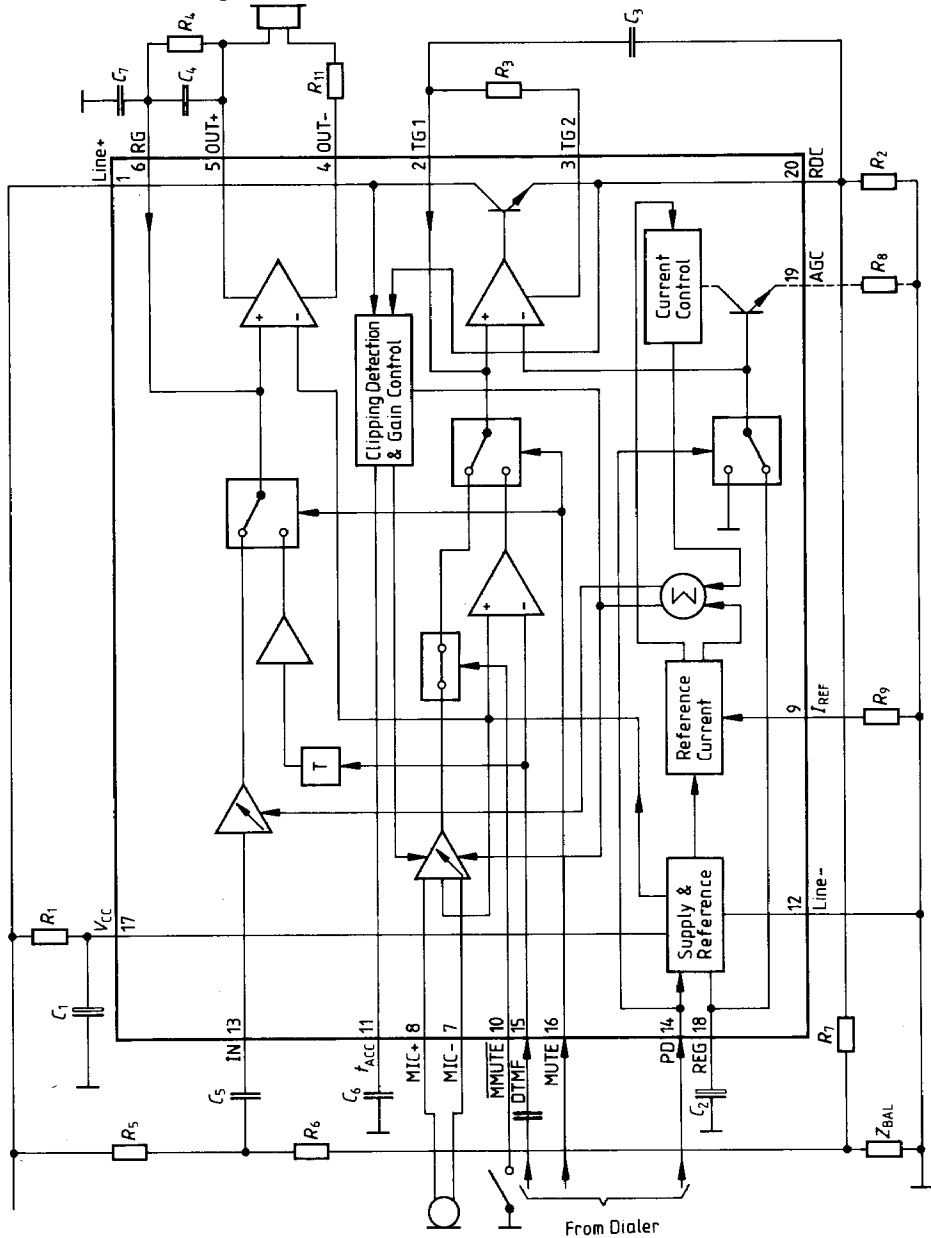
PSB 4500: Block Diagram and External Components



From Dialer

Figure 12b

PSB 4501: Block Diagram and External Components



Component	Function and Note	Recommended Value
R_1	<p>determines and dynamic resistance of the speech circuit</p> $R_1 = R_1 // R_{int} // R_{VA} \quad (1)$ <p>where $R_{int} = 18 \text{ k}\Omega$ is a equivalent internal resistance between Line + and REG</p> <p>R_{VA} = external resistor between Line + and REG if the voltage drop across the circuit has been reduced</p> <p>R_1 with C_1 provides a smoothed voltage V_{CC} for the IC itself and for the peripheral circuits (I_D);</p>	620 Ω
R_2	<p>determines the differential dc-resistance of the speech circuit</p> $R_{dc-diff} = R_2$ <p>and affects the voltage drop across the circuit</p> $V_{Line+} = V_{ref} + R_2 (I_{Line} - I_{CC} - I_{int} - I_p) \quad (2)$ <p>where V_{ref} = reference voltage (= 3.6 V for $I_{Line} \geq 11 \text{ mA}$)</p> <p>$I_{Line}$ = line current</p> <p>$I_{CC} = 1 \text{ mA}$</p> <p>$I_{int} = 0.5 \text{ mA}$</p> <p>I_p = current for external circuits</p> <p>It also determines the microphone gain (see note to R_3) and influences the gain-control characteristics;</p>	20 Ω
R_3	<p>determines the voltage gain in transmit direction; the gain for the microphone signal is</p> $A_M = 1.356 \times \frac{R_3 + r_d}{R_2 \times R_9} \times (R_l // R_l) \quad (3)$ <p>where R_l = determined by (1)</p> <p>R_l = line termination resistance-load at Line + during measurement</p> <p>$r_d = 3.47 \text{ k}\Omega$ is the dynamic resistance of the internal circuitry</p> <p>the gain of the DTMF dialing signal is 26 dB lower then that of the microphone amplifier.</p> <p>The gain can be set over a range of $\pm 8 \text{ dB}$ by means of R_3 between 25 $\text{k}\Omega$ and 180 $\text{k}\Omega$</p>	68 $\text{k}\Omega$ for test-condition

Component	Function and Note	Recommended Value
R_4	<p>determines the gain in receiving direction; the gain of the receiving amplification (between IN and the symmetrical outputs OUT + and OUT -) is given by</p> $A_{RS} = 2.628 \times \frac{R_4}{R_9} \times \frac{Z_T}{Z_T + 2 r_o} \quad (4)$ <p>where Z_T = impedance of the earpiece $r_o = 4 \Omega$ is the output impedance of the receiving amplifier. The gain can be adjusted over a range of ± 8 dB by means of R_4 between 40 kΩ and 250 kΩ.</p>	100 k Ω
R_5	<p>R_5, R_6, R_7, Z_{Bal} determines with R_1, R_2 and Z_{Line} the anti-side-tone network and attenuates the receiving signal before it gets to the receiving amplifier. Optimum anti-side-tone performance is given by</p> $Z_{Bal} = \frac{R_7}{R_i} \times Z_{line} \quad (5)$ <p>the attenuation of the received signal is</p> $\frac{V_{IN}}{V_{Line+}} = \frac{R_i/R_6}{R_5 + (R_i/R_6)} \quad (6)$ <p>where R_i = input impedance of the receiving amplifier (21 kΩ) $R_i = R_1$ given by (1) $R_2 < Z_{Bal}/R_7 < R_6$ The attenuation in a practical circuit is about 32 dB</p>	130 k Ω
R_6		3.9 k Ω
R_7		390 Ω
Z_{Bal}		130 Ω + 820 Ω // 220 nF
R_8	<p>determines the line current start-point where the gain of both microphone and receiving controller amplifier decreases as a function of increasing DC-line current.</p> $I_{Lstart} = 4.5 \times 10^{-6} \times \frac{R_8}{R_2} \quad (7)$ <p>The line current end-point to start-point given by ratio is approximately constant</p> $\frac{I_{end}}{I_{start}} = 2.5$ <p>If pin 19 is open the AGC is inoperative.</p>	100 k Ω

Component	Function and Note	Recommended Value
R_9	determines the current in an internal current-stabilizer. No alternative value is permissible.	3.6 k Ω
C_1	smoothing capacitor for the supply voltage at V_{CC} of the IC itself – (see also note to R_1).	100 μ F
C_2	smoothing capacitor decoupling the AC-signal from the DC regulation part	4.7 μ F
C_3	is necessary for ensuring the stability of the transmitting amplifier. In combination with R_3 it operates as a first-order low-pass filter in sending direction with a cut-off frequency determined by the time-constant $R_3 \times C_3$.	100 pF
C_4	is necessary to ensure the stability of the receiving amplifier where the time constant $R_4 \times C_4$ corresponds with the cut-off frequency of a first-order low-pass filter	100 pF
C_5	decouples the AC-signal for the receiving amplifier.	100 nF
C_6	determines the release time of the circuit after an over-drive condition in the transmit direction (turns out). The release time for each 3 dB overdrive, respectively with gain reduction, is approximately 6 ms. The capacitor will be recharged by an internal current source.	470 nF
C_7	is necessary for the stability of the receiving amplifier. The value of C_7 must be $10 \times C_4$.	1 nF
R_{VA}	affects the DC voltage drop across the circuit (see figure 3). R_{VA} connected between – Line + and REG decreases the voltage drop $V_{ref} = 1.3 \text{ V} + (R_{VA(1-18)} \parallel 16.3 \text{ k}\Omega) \times 0.14 \text{ mA}$ $V_{ref} (R_{VA} = 68 \text{ k}\Omega) \approx 3.15 \text{ V}$ – REG and RDC increases the voltage drop $V_{ref} = 2.93 \text{ V} + 21200 \text{ V}\Omega / (R_{VA(18-20)} \parallel 31.6 \text{ k}\Omega)$ $V_{ref} (R_{VA} = 39 \text{ k}\Omega) \approx 4.2 \text{ V}$.	68 k Ω 39 k Ω
Z_{Bal}	is a balancing network from the anti-side-tone circuit. See also R_5 , R_6 , R_7 .	

Figure 13

Alternative Microphone Arrangements

(a) magnetic or dynamic microphone. The resistor marked (1) may be used to lower the terminating impedance. In case of sensitive microphone types, a resistor attenuator can be used to prevent overloading of the microphone inputs (b) electret microphone, (c) piezoelectric microphone.

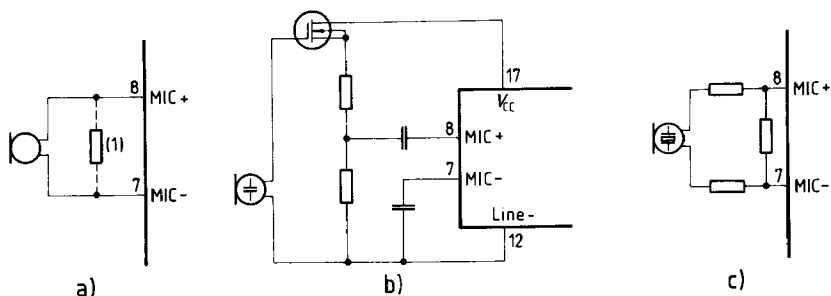
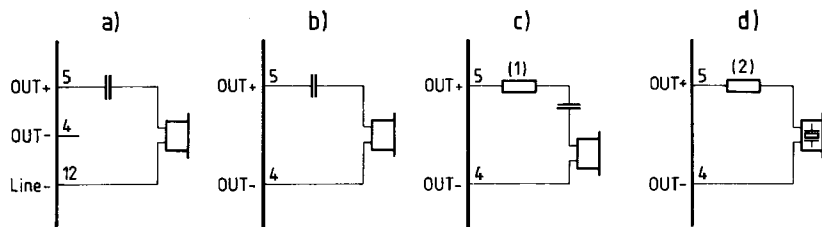


Figure 14

Alternative Receiver Arrangements

(a) dynamic telephone with less than 450 Ω impedance, (b) dynamic telephone with more than 450 Ω impedance. (c) magnetic telephone with more than 450 Ω impedance. The resistor marked (1) may be connected to prevent distortion (inductive load). (d) piezoelectric telephone. The resistor marked (2) is required to increase the phase margin (capacitive load).

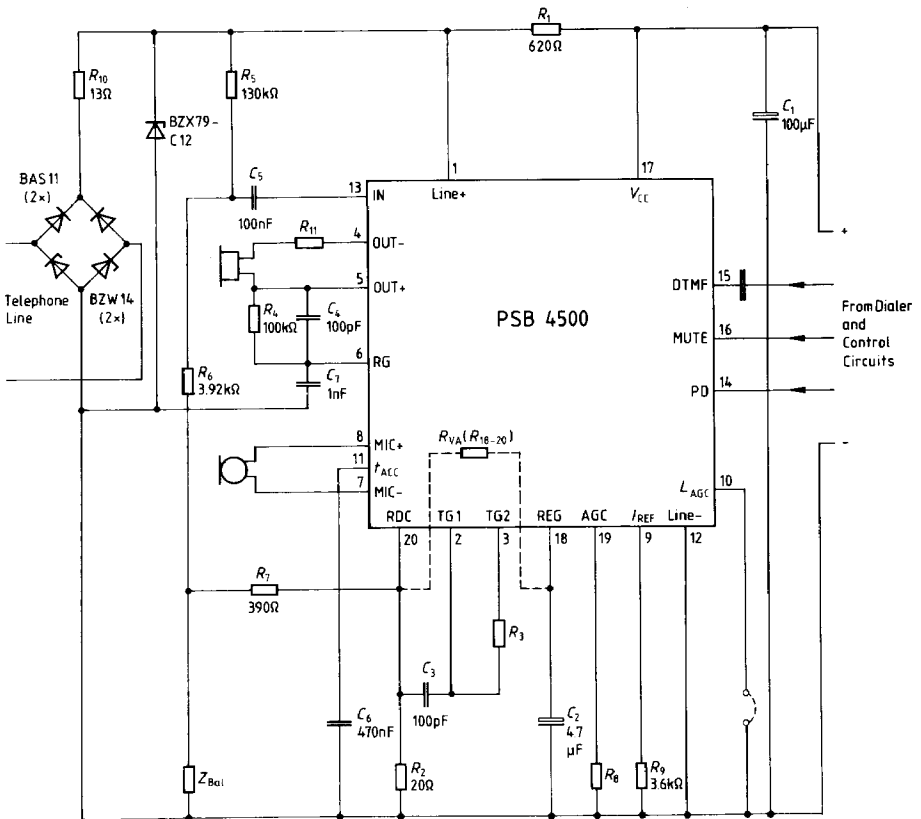


Application PSB 4500

Typical application of the PSB 4500, shown here with a piezoelectric earpiece and DTMF dialing. The bridge to the left, the Z-diode and R_{10} limit the current into the circuit and the voltage across the circuit during line transients. Pulse dialing or register recall require a different protection arrangement. By means of resistor R_{VA} (R_{18-20}) the dc line voltage can be set to a higher value.

The AGC range is 6 dB if pin 10 (L_{AGC}) is connected to ground and 3 dB if pin 10 is open.

Figure 15a

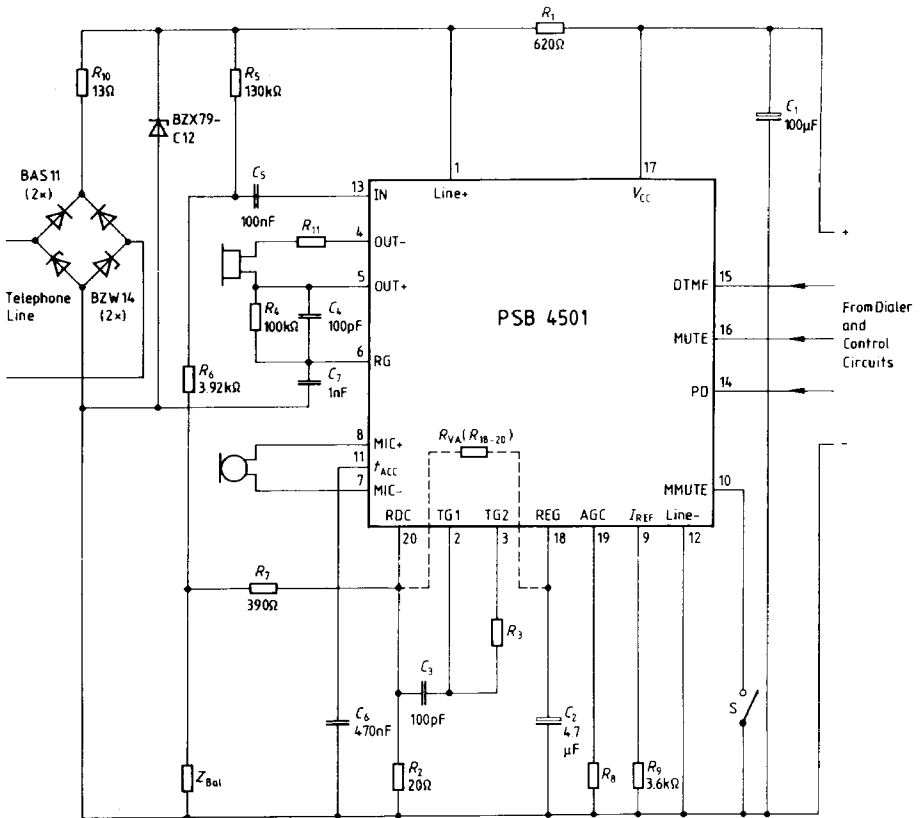


Application PSB 4501

Typical application of the PSB 4501, shown here with a piezoelectric earpiece and DTMF dialing. The bridge to the left, the Z-diode and R_{10} limit the current into the circuit and the voltage across the circuit during line transients. Pulse dialing or register recall require a different protection arrangement. By means of resistor R_{VA} (R_{18-20}) the DC line voltage can be set to a higher value.

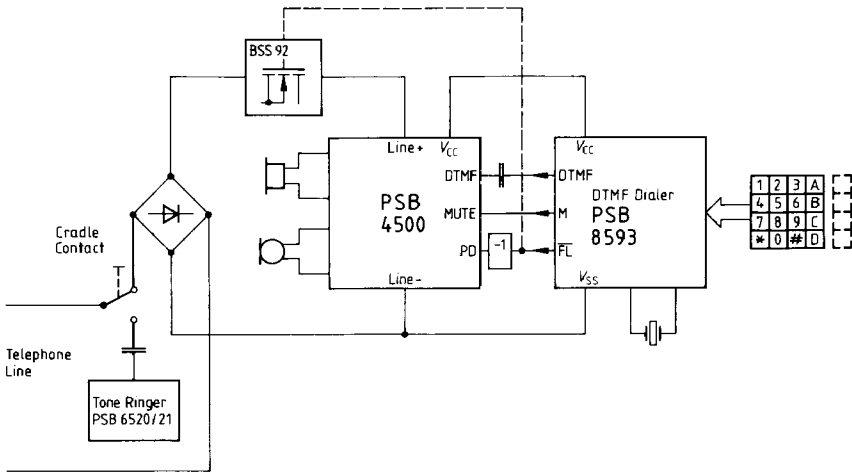
Switch S between pin 10 and line represents the MMUTE key.

Figure 15b



Typical Application (simplified)

- a) DTMF dialing circuit implemented with CMOS circuit PSB 8593.
The dashed lines show an optional flash (register recall by timed loop break)
- b) Application circuit with pulse and DTMF bilingual dialer PSB 8510.



a)

