ERICSSON

February 1996

PBL 3881 Voice-switched Speakerphone Circuit

Description

The PBL 3881 contains all the necessary circuitry, amplifiers, detectors, comparators and control functions to implement a high performance, voice-switched, loudspeaking, ”hands-free ” telephone. The gain dynamics (attenuation between channels) is continuously adjustable (0-50 dB) via a separate pin. A background noise detector in the transmitting channel reduces the influence of continuous noise signals.

The PBL 3881 is designed for telephone line powered applications. The circuit contains a transformerless power amplifier with a current supply circuitry that eliminates the need of inductors (patented). Automatic volume attenuation in the power amplifier extends the operating range at low line currents.

Filtering of the signals in both transmitter and receiver channels is possible. Optional AGC function can be implemented into the receiver channel.
All pinnumbers refer to 22-pin DIP-package unless otherwise noted.

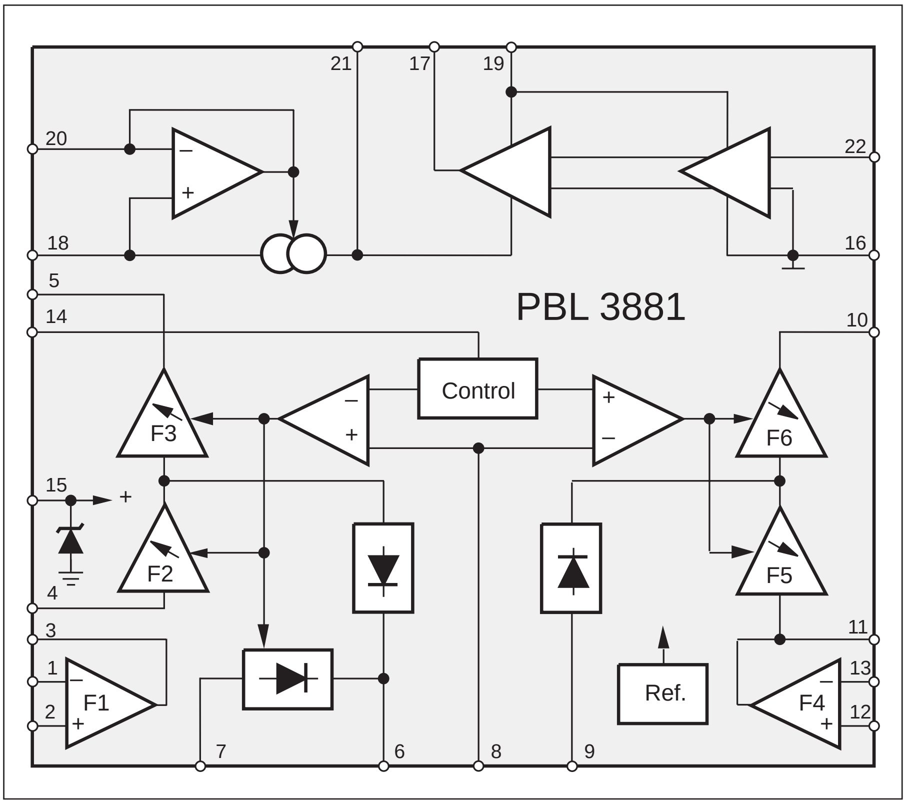
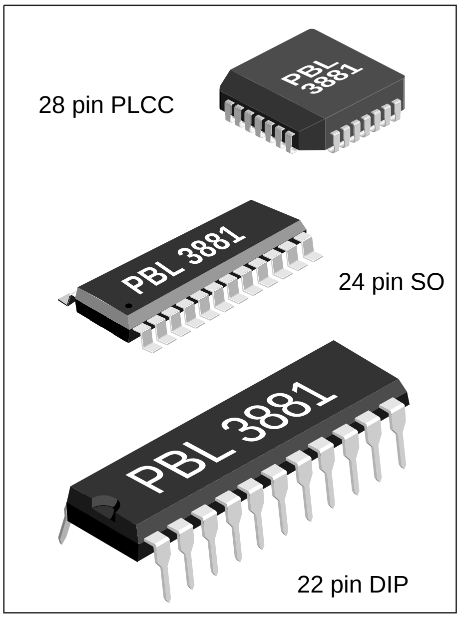


Figure 1. Block diagram.

Key Features

- Adjustable gain range in the attenuated channel (0 - 50 dB).
- Direct telephone line powered solution (patented).
- Low power consumption, 2.2 mA at 3.2 V (typical).
- Direct drive of an 25 - 50 ohm loudspeaker.
- 22-pin dual in-line plastic, 24-pin SO and 28-pin PLCC encapsulation.
- Background noise compensation in the transmitting channel.
- Good noise performance.
- Fully accessible in - and outputs of the channel input amplifiers.
- Minimum of external components needed for function.



Maximum Ratings

Parameter	Symbol	Min	Max	Unit
Speech switch supply current	I_D		10	mA
Speaker amplifier supply current	I_{+L}		200	mA
Operating temperature	T_{Amb}	-20	70	°C
Storage temperature	T_{Stg}	-55	125	°C

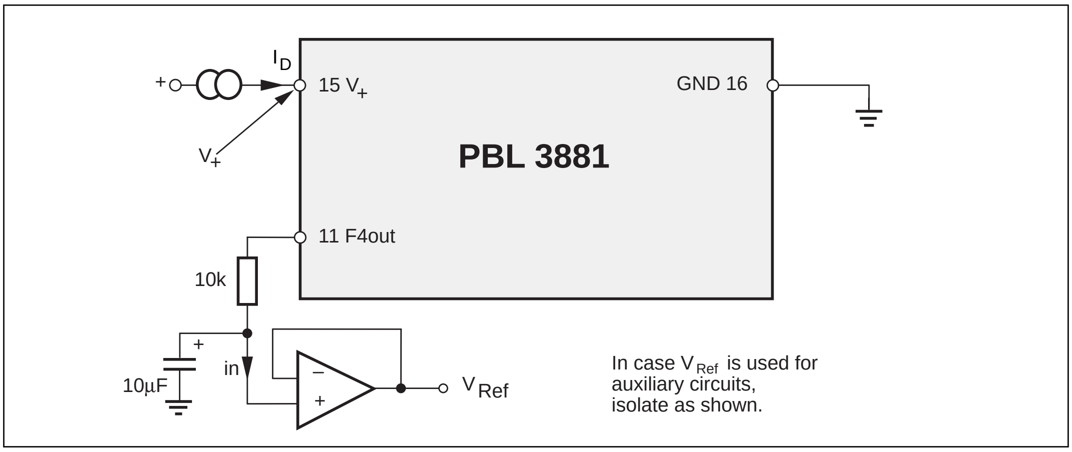


Figure 2. Isolation and measurement of V_{Ref}. Ref fig No.2.

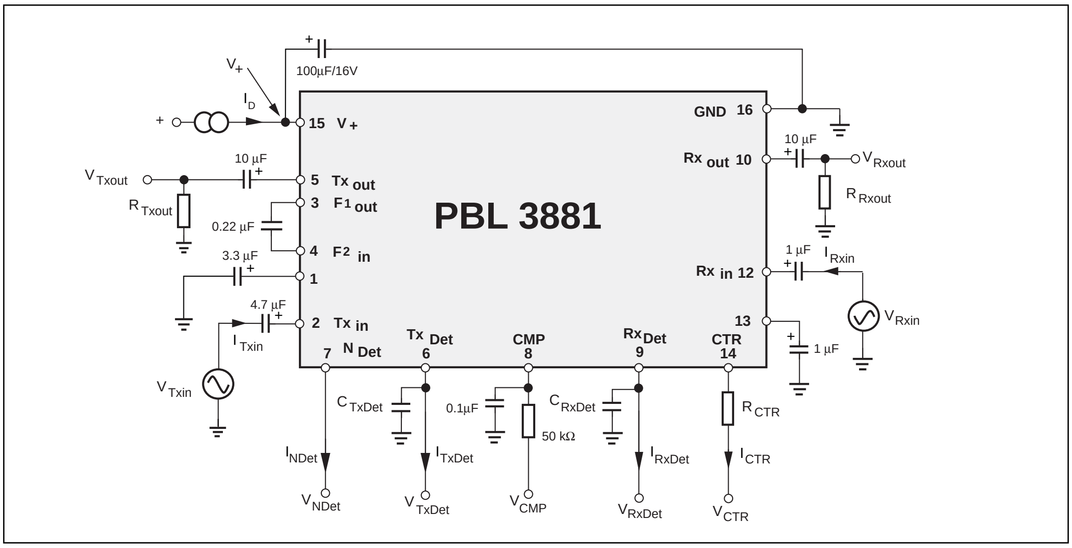


Figure 3. Test circuit. Reference figure No. 3.

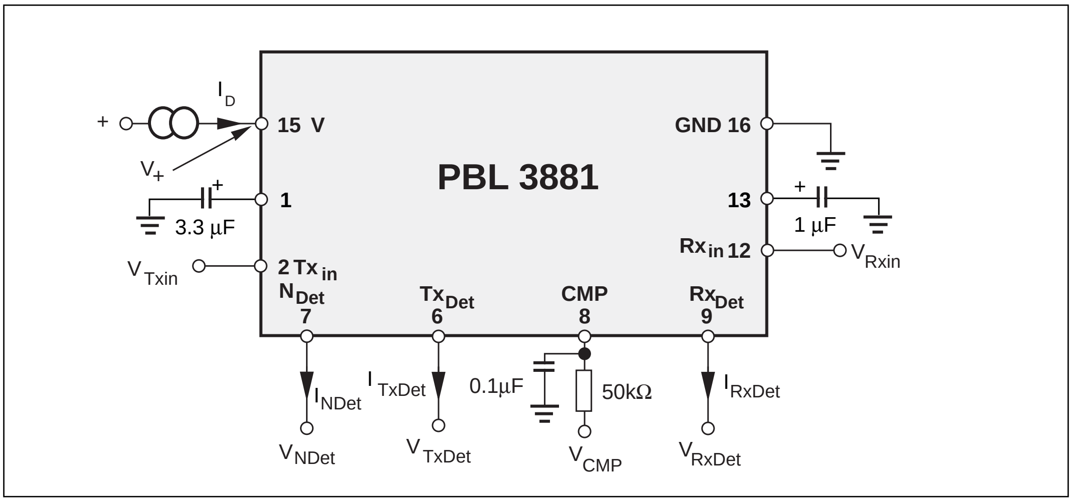


Figure 4. Test circuit. Reference figure No. 4.

Electrical Characteristics

V_+ = 3.4 V, f = 1 kHz, T = 25°C, R_{CTR}=0, C_{TxDet} = 0, R_{Txout} =00, R_{Rxout}=00, R_{CTR}=00 and C_{RxDet} = 0 unless otherwise noted.

Parameter	Ref. fig.	Condition	Min.	Typ.	Max.	Unit.
Speech control section						
Terminal voltage, V_+	3	I_D = 1.7mA $V_{CTR} \le$ 1.6 V, R_{CTR} = 0Ω	3.2			V
	3	I_D = 1.15mA $V_{CTR} \le$ 1.6 V, R_{CTR} = 0Ω		03.2		V
Internal reference voltage, V_{Ref}	2			1.90		V
Supply current I_D	3	V_+ = 3.2 V		1.15	1.70	mA
Frequency response for all amplifiers	3	200 - 3400 Hz, Relative 1 kHz	-1		1	dB
Transmit gain, $20 \bullet {}^{10}\log(V_{Txout}/V_{Txin})$	3	$V_{CMP} = V_{Ref}$ + 0.1 V	41.5	44		dB
		$V_{CMP} = V_{Ref}$ – 0.1 V		-6	-3.5	dB
Receive gain, $20 \bullet {}^{10}\log(V_{Rxout}/V_{Rxin})$	3	$V_{CMP} = V_{Ref}$ - 0.1 V	26.5	29		dB
		$V_{CMP} = V_{Ref}$ + 0.1 V		-21	-18.5	dB
Max transmit detector gain,	3	V_{TxDet} < 200 mV_p				
$20 \bullet {}^{10}\log(V_{Txdet}/V_{Txin})$		$V_{CMP} = V_{Ref}$ + 0.1 V		67.5		dB
		$V_{CMP} = V_{Ref}$ – 0.1 V	37	42.5		dB
Max receive detector gain,	3	V_{RxDet} < 200 mV_p				
$20 \bullet {}^{10}\log(V_{Rxdet}/V_{Rxin})$		$V_{CMP} = V_{Ref}$ - 0.1 V		53		dB
		$V_{CMP} = V_{Ref}$ + 0.1 V	22.5	28		dB
Noise rectifier gain, (note 1)	3	$V_{CMP} = V_{Ref}$ + 0.1 V, C_{Txdet}=1µF		6.0		dB
		$V_{CMP} = V_{Ref}$ - 0.1 V		Hold		
+ Tx_{In} input impedance, V_{TxIn}/I_{TxIn}	3		80	100	120	kΩ
- Tx_{In} input impedance, v_{TxIn} / I_{TxIn}	3		2.5	3.2	3.9	kΩ
+ Rx_{In} input impedance, V_{RxIn}/I_{RxIn}	3		80	100	120	kΩ
- Rx_{In} input impedance, v_{RxIn} / I_{RxIn}	3		8	10	12	kΩ
Tx_{Out} ac, load impedance	3		25			kΩ
Rx_{Out} ac, load impedance	3		25			kΩ
Dynamics		2% distortion,R_{Txout}=R_{Rxout}=25k Ω				
Transmit output, v_{TxOut}	3	V_+ = 3.5 V		500		mV_p
		I_D = 1.15 mA		250		mV_p
Receive output, v_{RxOut}	3	V_+ = 3.5 V		500		mV_p
		I_D = 1.15 mA		250		mV_p
Noise,						
Transmit output, v_{TxOut}	3	$V_{CMP} = V_{Ref}$ + 0.1 V, v_{TxIn} = 0 V		-7		dB_{psof}
Receive output, v_{RxOut}	3	$V_{CMP} = V_{Ref}$ - 0.1 V, v_{RxIn} = 0 V		-80		dB_A
Tx_{Det} source current, I_{TxDet}	4	$V_{TxIn} = V_{Ref}$ + 0.1 V, $V_{CMP} = V_{Ref}$ + 0.1 V, $V_{TxDet} = V_{Ref}$	2.5	6.0		mA
Rx_{Det} sink current, I_{RxDet}	4	$V_{RxIn} = V_{Ref}$ + 0.1 V, $V_{CMP} = V_{Ref}$ - 0.1 V, $V_{RxDet} = V_{Ref}$		-6.0	-2.5	mA
Tx_{Det} sink current, I_{TxDet}	3	$V_{CMP} = V_{Ref}$ + 0.1 V, V_{TxIn} = 0, $V_{TxDet} = V_{Ref}$ + 0.7 V	-30			µA
Rx_{Det} source current, I_{RxDet}	3	$V_{CMP} = V_{Ref}$ - 0.1 V, V_{RxIn} = 0, $V_{RxDet} = V_{Ref}$ - 0.7 V			30	µA
Tx_{Det} swing relative to V_{Ref}, V_{TxDet}	4	$V_{CMP} = V_{Ref}$ + 0.1 V, $V_{Txin} = V_{Ref}$ + 0.1 V	(note 2)	+0.7		V
Rx_{Det} swing relative to V_{Ref}, V_{RxDet}	4	$V_{CMP} = V_{Ref}$ - 0.1 V, $V_{Rxin} = V_{Ref}$ - 0.1 V	(note 2)	-0.7		V
N_{Det} source current (fast charge), I_{NDet}	4	V_+ = 2.8 V, $V_{CMP} = V_{Ref}$ + 0.1 V, $V_{NDet} = V_{Ref}$ - 0.45 V,V_{Txin}=0	1.5	4.5		mA
N_{Det} sink current, I_{NDet}	4	$V_{CMP} = V_{Ref}$ + 0.1 V, $V_{NDet} = V_{Ref}$ -0,2 V $V_{Txin} = V_{Ref}$ + 0.1 V	-7	-5	-3	µA

Parameter	Ref. fig.	Conditions	Min.	Typ.	Max.	Unit.
N_{Det} leakage current (hold), I_{NDet}	3	$V_{CMP} = V_{Ref}$ - 0.1 V, $V_{NDet} = V_{Ref}, V_{Txin}=0$		-100		nA
N_{Det} swing relative to V_{Ref}, V_{NDet}	4	$V_{CMP} = V_{Ref}$ + 0.1 V, $V_{Txin} = V_{Ref}$ + 0.1 V		-0.45		V
CMP (comparator) sensitivity, transmit (Tx) mode to receive (Rx) mode or vice versa	3 15	Tx mode = max Tx gain, Rx mode = max Rx gain		50	100	mV
CTR voltage for full duplex, V_{CTR}	3	$V_{CMP} = V_{Ref} \pm 0.35$ V		V_+		V
CTR sink current for mute, I_{CTR}	3	$V_{CMP} = V_{Ref} \pm 0.35$ V, R_{CTR}=1k Ω	50		60	µA
CTR voltage for shut down, V_{CTR}	3				0.55	V
Loudspeaker amplifier						
Operating voltage, V_A	5		2.5		12	V
Current consumption (no signal), I_{+L}	5	V_A = 3.0 V		1	2.3	mA
	5	V_A = 5.0 V		1.5		mA
	5	V_A = 12.0 V		4	9	mA
	21	R_E = 1.5 K, V_{Line} = 3.0 V Note 3 V_{RDC} = 0.35 V		1.3	2.4	mA
	21	R_E = 1.5 K, V_{Line} = 12.0 V Note 3 V_{RDC} = 5.0 V		7.5	14	mA
Current consumption (output swing at 5% dist.)	5	V_A = 3.0 V		7		mA
	5	V_A = 5.0 V		13		mA
	5	V_A = 12.0 V		30		mA
Swing at 5% dist., V_{Out}	5	V_A = 3.0 V	0.6	0.85		V_p
	5	V_A = 5.0 V	1.5	1.7		V_p
	5	V_A =12.0 V	3.6	4.0		V_p
Gain	5	V_A =5.0 V	34.5	36.5	38.5	dB
Frequency response	5	200 to 3400 Hz, relative 1kHz, V_A = 5.0 V	-1		1	dB
Amplifier power efficiency (5% dist), n	5	V_A = 3.0 to 12.0 V, n = n (%)=/00 • P_{Load}/P_{Supply}		40		%
Input impedance pin 22	5		24	30	36	kΩ

Notes

1. $20 \cdot {}^{10}\log \left(\frac{V_{NDet} - V_{Ref}}{V_{TxDet} - V_{TxDetO}} \right)$

V_{NDet} = voltage at noise detector output

V_{Ref} = reference voltage (about 1.9 V) see figure 2.

V_{TxDet} = Voltage at transmit detector output.

V_{TxDetO} = voltage at transmit detector output at the point when the voltage at the noise detector starts moving when a signal at transmit channel input is gradually increased (threshold, typical value 30 mV)

2. Depends on V_+. Channels are tracking.
3. $V_{Line} = V_A + V_{DRC}$

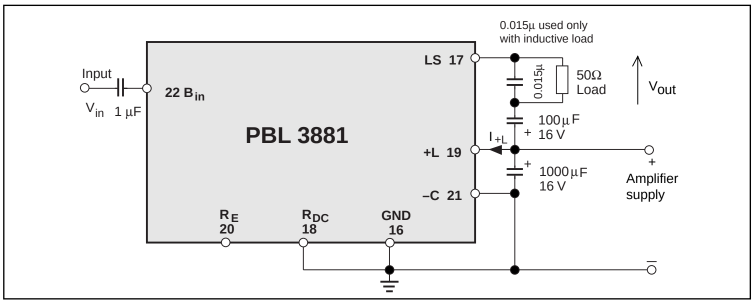


Figure 5. Test circuit. Reference figure No. 5.

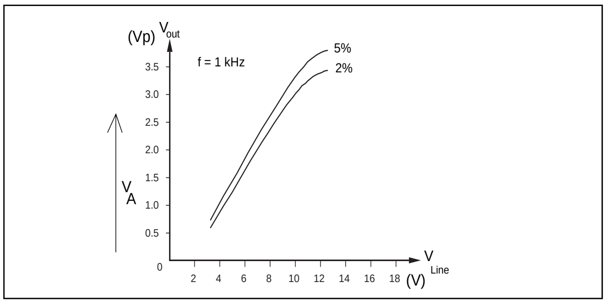


Figure 6. Power amplifier output distorsion. Line voltage versus output swing.

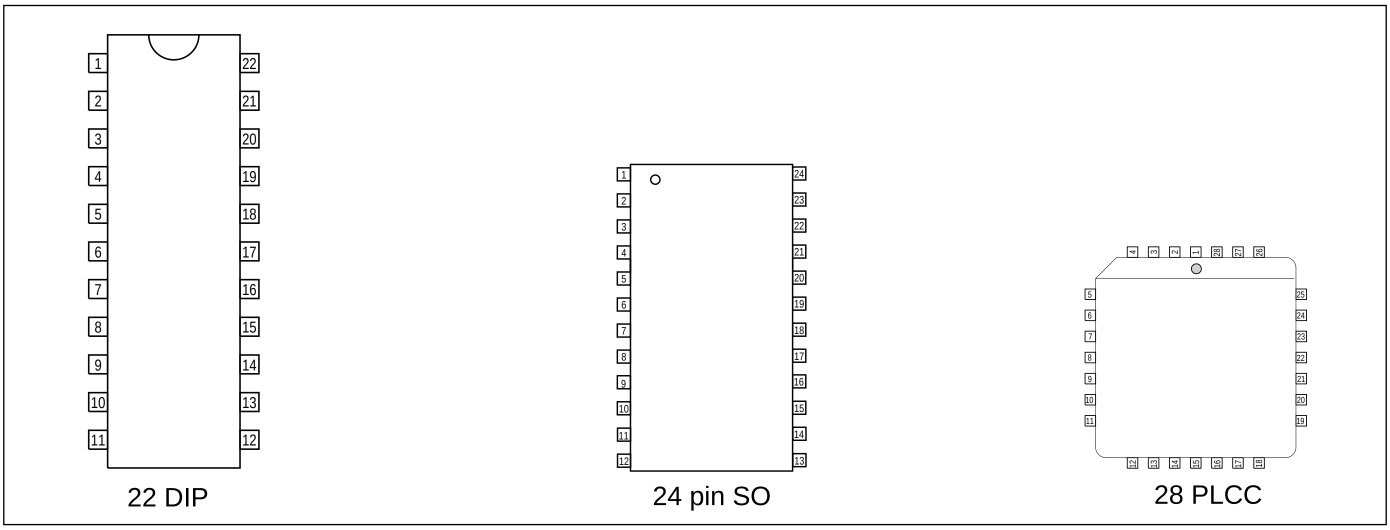


Figure 7. Pin configuration.

Pin Descriptions

Refer to figure 7. (22-pin dual-in-line package, 24pin SO package and 28-pin PLCC package)

22-Pin DIP	24-pin SO	28-Pin PLCC	Symbol	Description
1	24	1	$- Tx_{In}$	Transmitter channel negative input. Input impedance 3.16 kohm.
2	1	2	$+ Tx_{In}$	Transmitter channel positive input. Input impedance 100 kohm.
3	2	3	$F1_{Out}$	Output of the first amplifier in the transmitter channel.
4	3	4	$F2_{In}$	Input of the second amplifier in the transmit channel. Input impedanc varies with gain of F_2 from 20 kohm at high gain to 89 kohm at low gain.
5	4	5	Tx_{Out}	Transmitter channel output. Min. ac.load impedance 25 kohm.
6	5	6	Tx_{Det}	Transmitter signal detector output. Goes positive in reference to the internal reference voltage,1.9 V, when a transmitt signal is present.
7	7	9	N_{Det}	Background noise detector output. Goes negative in reference voltage, to the int. reference voltage 1.9V when a noise of a longer duration appears.
8	8	10	CMP	Comparator input. External resist-ance to this input should be 50 kohm. Summing point to the different detector outputs.
9	9	11	Rx_{Det}	Receiver signal detector output. Goes negative in reference to the internal reference voltage, appro-ximately 1.9 V, when signal is present at Rx_{In}.
10	10	12	Rx_{Out}	Receiver channel output. Min. ac.load impedance 25 kohm.
11	11	13	$F4_{Out}$	Output of the first and input of the second amplifiers in the receiver channel.Sense point for the internal reference voltage.
12	12	14	$+ Rx_{In}$	Receiver channel positive input. Input impedance 100 kohm.
13	13	15	$- Rx_{In}$	Receiver channel negative input. Input impedance 10 kohm.
14	14	16	CTR	Control input for gain dynamics, mute, and shut down.
15	15	17	V_+	Supply for the speech-switching circuitry. A shunt regulator voltage approximately 3.2 V at 1.5 mA.
16	16	20	GND	System ground (-line).
17	17	23	LS	Loudspeaker power amplifier output.
18	19	24	R_{DC}	Pins for loudspeaker amplifier supply options. Described in the text.
20	21	26	R_E	
21	22	27	-C	
19	20	25	A	Positive supply for the loud-speaker amplifier.
22	23	28	B_{In}	Signal input for the loudspeaker amplifier. Input impedance 30 kohm.
	6	7	NC	
		8	NC	
	18	18	NC	
		19	NC	
		21	NC	
		22	NC	

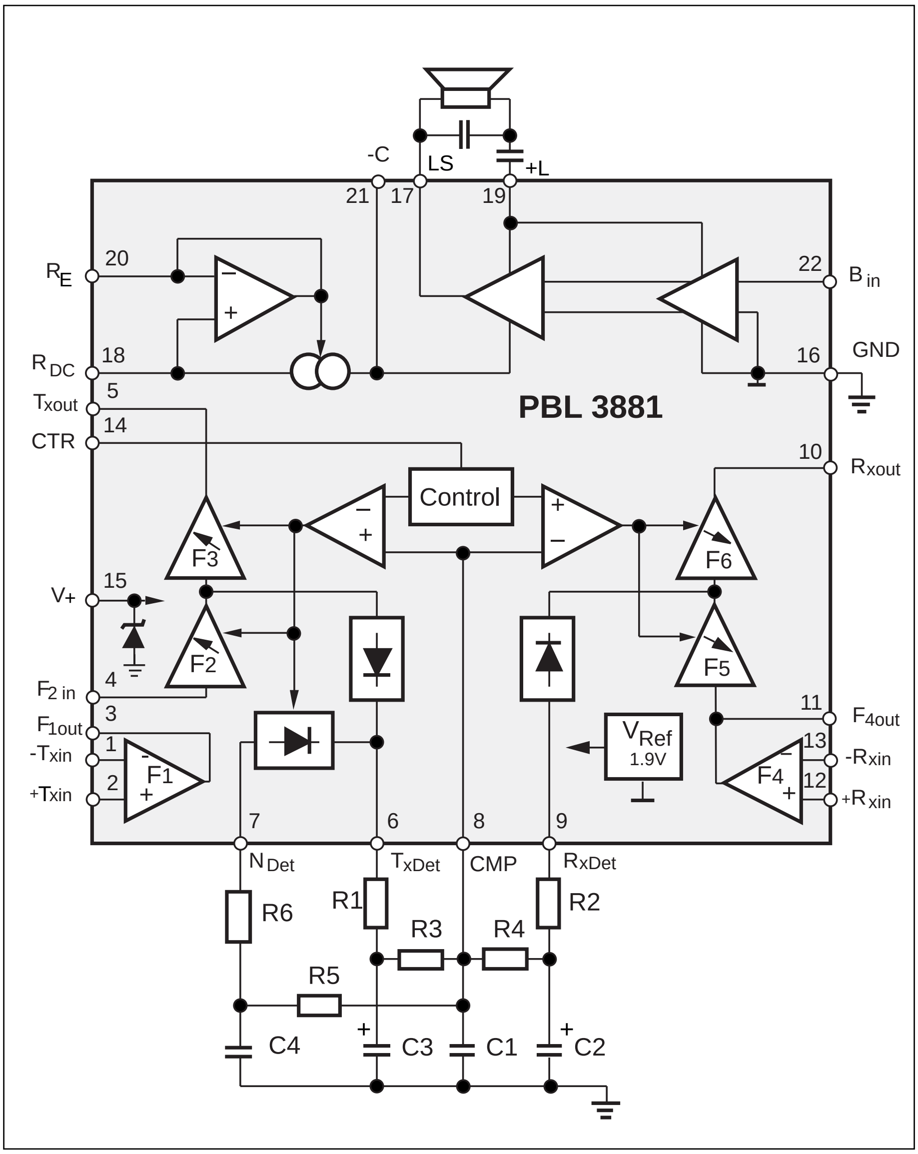


Figure 8. Passive networks setting the speech control function.

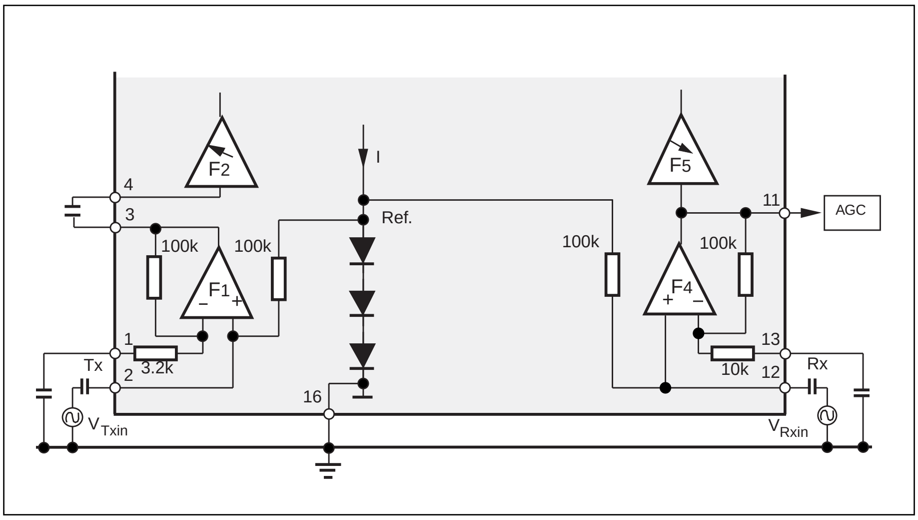


Figure 9. Receive and transmit channel input arrangement.

Functional Description Speech control section.

Transmitter and Receiver Channels

The transmitter and receiver channels consist of three amplifying stages each, F1, F2, F3 and F4, F5, F6. The inputs and outputs of the amplifiers must be ac. coupled because they are dc. vise at the internal reference voltage (≈1.9 V) level. F1 and F4 are fixed gain amplifiers of 30 dB and 20 dB respectively, while the rest of them are of controlled gain type. The gain of F2, F3 as well as F5 and F6 is controlled by comparators. The comparators receive their information partly from the summing point of the transmitter, receiver and background noise detectors at CMP input and partly through the control input, CTR, which controls the gain dynamics (0-50 dB). Amplifiers F2 and F3 have the maximum gain when the transmitter channel is fully open, consequently the amplifiers F5 and F6 will have minimum gain and vice versa. See figure 8. and figure 15.

The positive input on each channel has a high input impedance. It renders a good gain precision and noise performance when used with low signal source impedance. The negative input of the receiver channel should be returned to ground with a capacitor. The differential input of the transmitter channel can be used to suppress unwanted signals in the microphone supply, see figure 10. Also see application 1.

The output of the transmitter channel input amplifier (F1) and the input of (F2) are made accessible in order to allow filtering in the channel. The output of F4 can be used to implement an optional AGC (**A**utomatic **G**ain **C**ontrol) system in the receiver channel. The maximum dynamic range of the AGC can be made the same as the gain of F4. See figure 11.

Signal Detectors and Comparators

The signal detectors sense and rectify the receiver and microphone signals to opposite polarities referenced to the internal reference voltage of approx. 1.9 V. The voltage at Rx_{Det} will go negative and at Tx_{Det} positive in the presence of a signal at the respective channel input. In the idle (no signal) state, the voltage at Rx_{Det}, Tx_{Det} and CMP is equal to the internal reference voltage

Figure 10. Transmitter channel input amplifier used to suppress ripple in the mic. supply. (CMRR). R1 is used to establish a balansed input.
R1 = R2 ≈ 3k2
R3 = R4 ≈ 100k
R5 = R6
C1 = C2

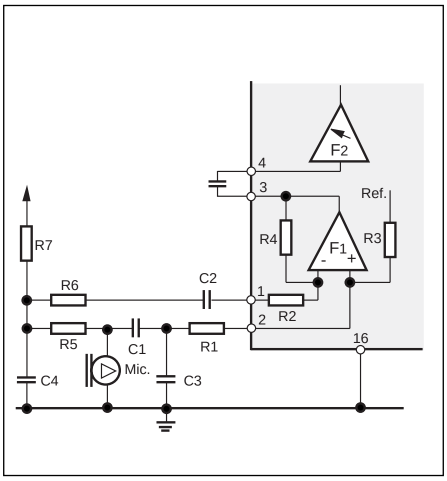
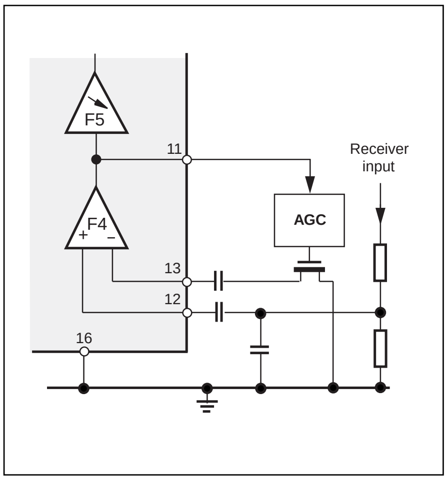


Figure 11. Receiver channel with optional AGC arrangement.



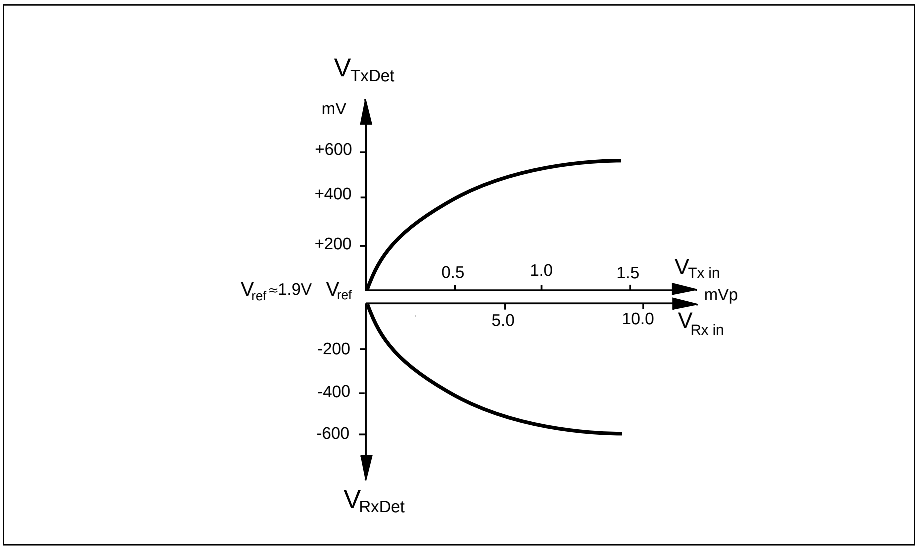


Figure 12. Transmitter and receiver channel rectifier characteristics.

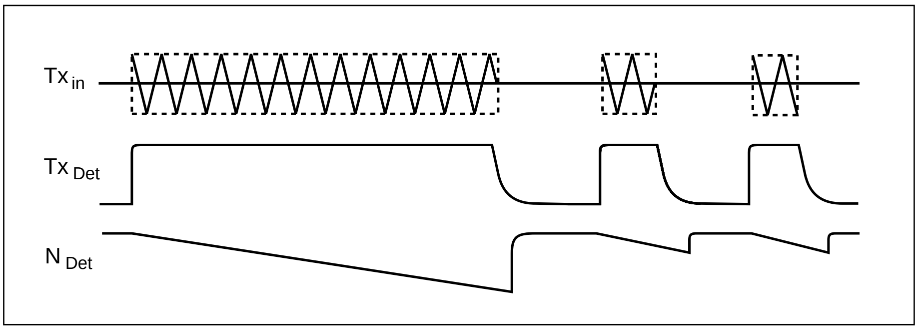


Figure 13. Relationship in timing between the voltage levels at Tx_{In}, Tx_{Det} and N_{Det}

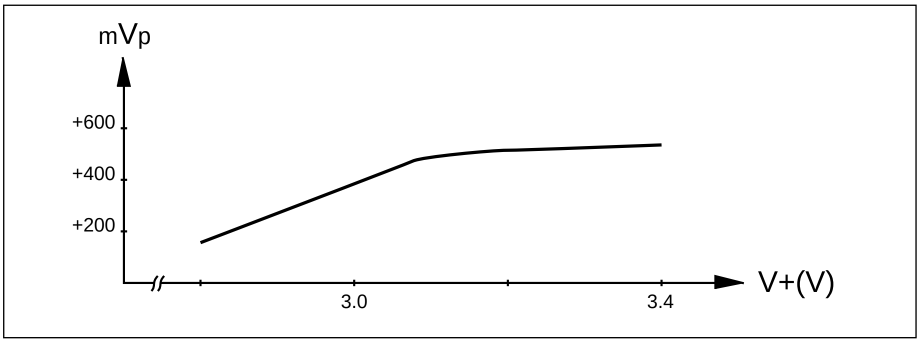


Figure 14. Transmitter and receiver channel output dynamics.

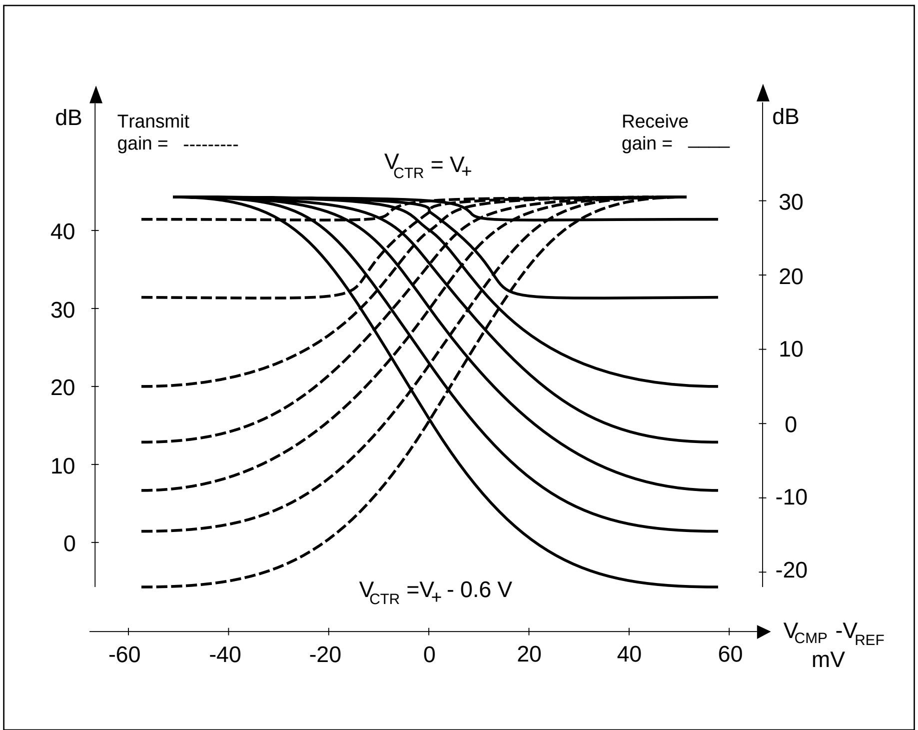


Figure 15. Transmit and receive gain as a function of V_{CMP} and V_{Ref}.

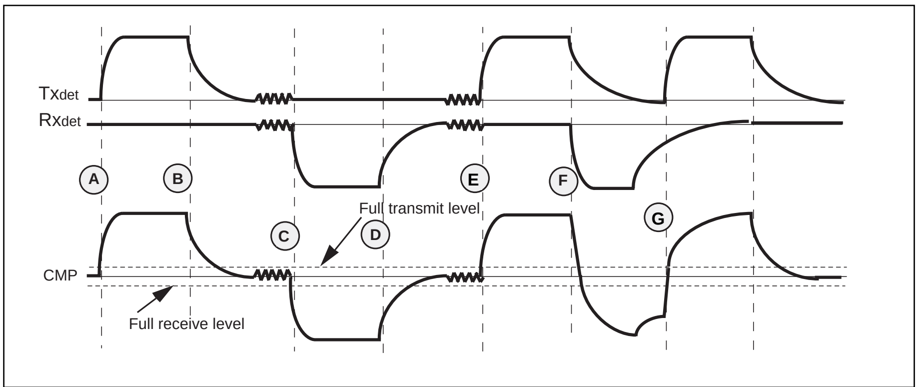


Figure 16. Timing of the transmitter and receiver channels at the CMP-input.

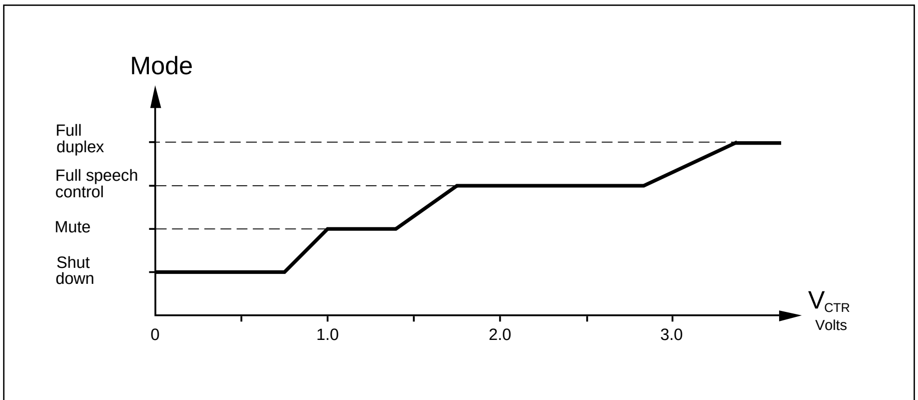


Figure 17. Control modes as function of voltage applied to gain dynamics control input CTR at $V_+ = 3.4$ V.

of 1.9 V. Signal at Tx_{in} will result in an increased level at Tx_{Det} and hence also at CMP input. The comparators will increase the gain in the transmitter channel and decrease it in the receiver channel. Signal at Rx_{in} will do vice versa. Thus the voltages Rx_{Det} and Tx_{Det} control the gain setting in respective channel through the comparators using the CMP input as a summing point with an input current of less than 1µA. The attack and decay times for the signals Rx_{Det} and Tx_{Det} are controlled by individual external RC-networks. The attack time in the receiver channel is set by C_2 together with C_1 and either by the maximum current capability of the detector output or it with R_2 added. The transmitter channel works likewise. See fig. 8.

The decay time in the receiver and transmitter channels is set by C_2 and C_3 respectively. The resistor in the time constant is formed by an internal 100kΩ resistor in parallel with the external resistors R_3 and R_4 respectively. The influence of eventual R_1 and R_2 can be omitted.

The text above describes the case when only one channel is open at a time and there is a distinctive pause between signals at receiver and transmitter channel inputs so the circuit will have time to reach its idle state. See fig.16 A) to E). If one of the channels gets an input signal immediately after the signal has disappeared from the other channel input the effective decay time, as the CMP input sees it, will be shorter than in the first case. See fig. 16 F) to G). The capacitor C_1 at CMP - input sets the speed of the gain change in the transmitter and receiver channels. The capacitors C_2 and C_3 should be dimensioned for a charging time of 0.5 - 10 ms and for a discharge time of 150 - 300 ms. The question of switching times being a highly subjective proposition, is in large dependent of the language being spoken in the system, caused by the varying sound pressure picture of the different languagues. The total external resistance being presented for the CMP - input should be approx. 50 k (internal balance requirement). A hysteresis effect is achieved in the switching since the level detectors sense the signals after F_2 and F_5 respectively (F_2 and F_5 are affected by the gain setting). For example: If the transmitter channel is open (maximum gain), a smaller signal at Tx_{in} is enough to keep the channel open than would be

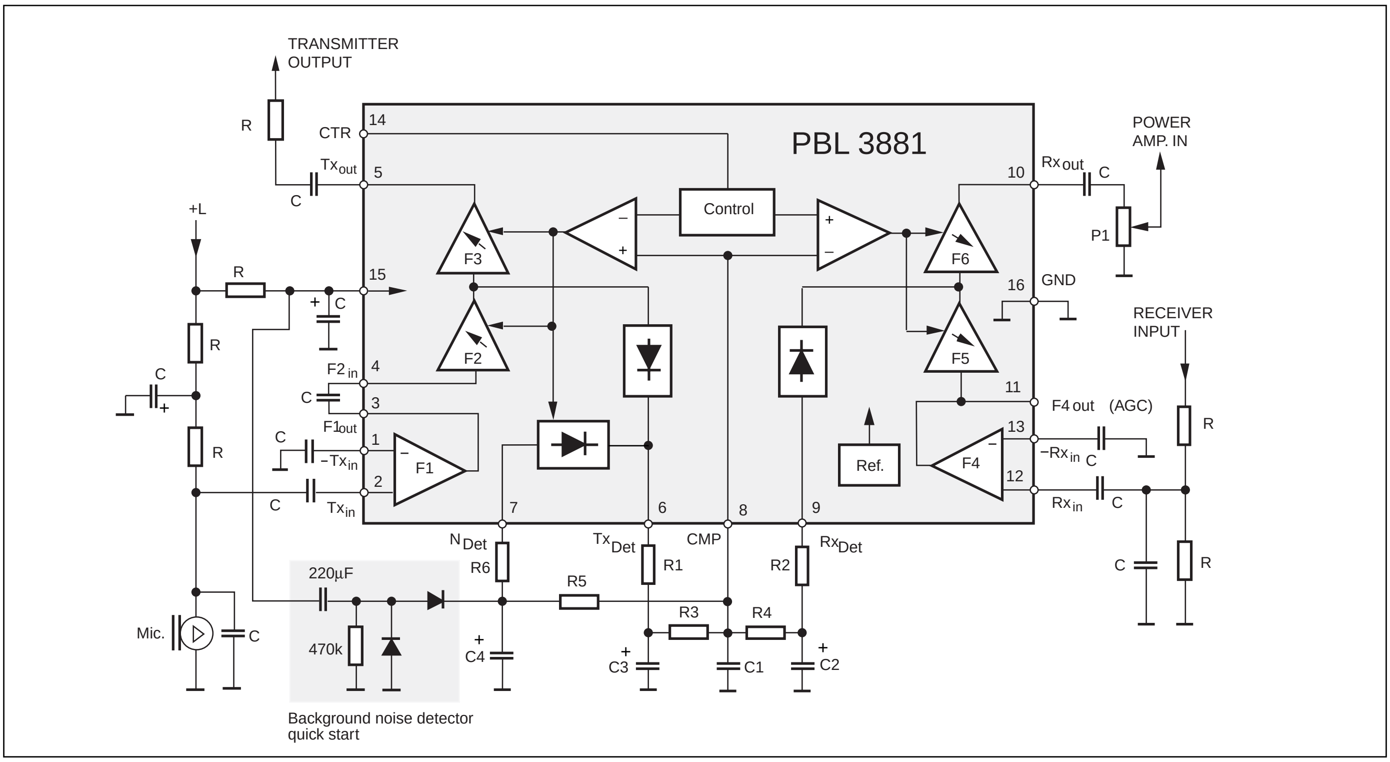


Figure 18. Speech switching arrangement.

necessary to open it when the receiver channel is open. The output swing of the level detectors is matched for variations in the supply voltage. The detectors have a logarithmic rectifier characteristic whereby gain and sensitivity is high at small signals. There is a break point in the curve at a level of ± 200 mV from the internal reference voltage 1.9 V, where the sensitivity for increasing input signals decreases by a factor of 10, increasing the detectors dynamic range.
See fig. 12.

Background Noise Detector

The general function of the background noise detector in the transmittng channel is to create a negative signal (in respect to the reference) so that, when coupled to the summing point at the CMP input, will counteract the signal from the transmitter level detector representing the actual sound pressure level at the microphone. This counteracts the noise from influencing the switching characte-ristics. The input signal to the backround noise level detector is taken from the output of the transmitter detector, a voltage representing the envelope of the amplified microphone signal. The detector inverts and amplifies this signal 2 x (transmitting mode) and has on it´s

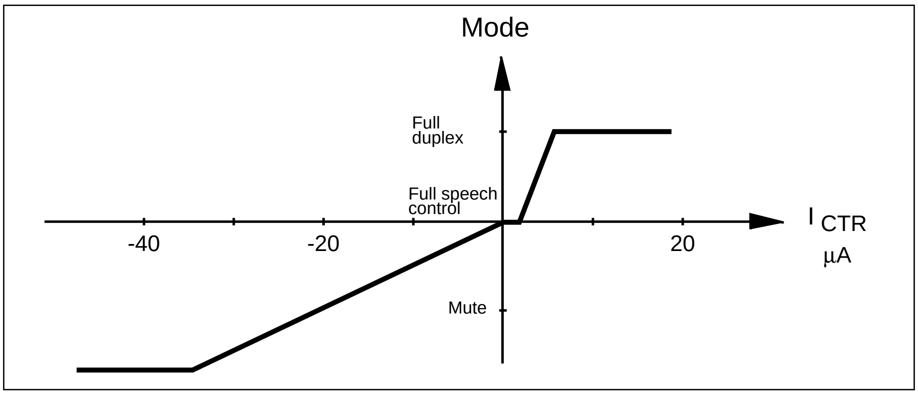


Figure 19. Control modes as function of current applied to gain dynamics control input CTR pin.

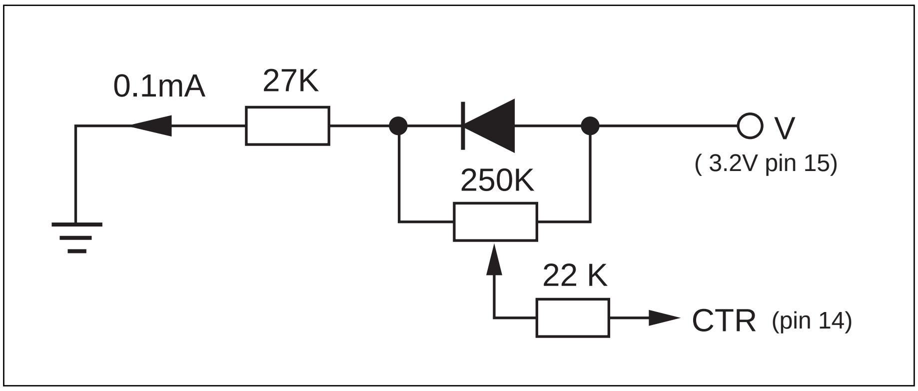


Figure 20. The control input voltage arrangement, from full duplex to full speech control.

output a RC network consisting of an internal resistor of 100k and an external capacitor C_4. The voltage across C_4 is connected to the CMP input (summing point) via a resistor R_5. The resistor R_6 is important in order to keep the charging current of C_4 within safe limits in regard of high charge peaks that could be audible in the system. The extent to which the N_{Det} output will influence the potential at CMP input is set by the gain of the detector, the maximum swing and R_5. If a continuous input signal is received from the microphone (> 10sec.) the voltage across C_4 is pulled negative (relative to the reference) with a time constant set by C_4 to e.g. 5 sec. A continuous input signal is thus treated as noise. Since the output of the noise detector is going negative it thereby counteracts the signal from the transmitter detector and thus helping the receiver detector signal to maintain a set relation to the transmitter detector signal. If the transmitter input signal contains breaks like breath pauses the voltage at Tx_{Det} output decreases. If the voltage across C_3 gets less than the inverted voltage across C_4 divided by the detector gain a rapid charge of C_4 towards reference will follow (all levels referred to the reference). If the breaks are frequent as in speech the background detector will not influence the switching characteristic of the system. See fig.13. There is a threshold of approx. 50 mV at Tx_{Det} to prevent the activation of background noise detection in noiseless environment. In the receive mode some of the loudspeaker output signal will be sensed by the microphone. In order not to treat this input signal as noise, the noise detector goes into a hold state and ”remembers” the level from the previous

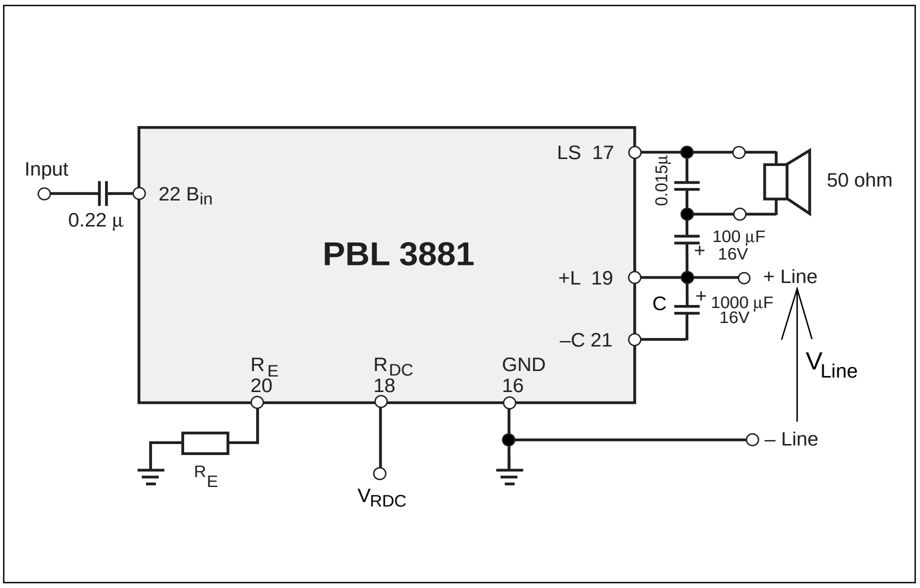


Figure 21. Power supply in parallel with speech circuit.

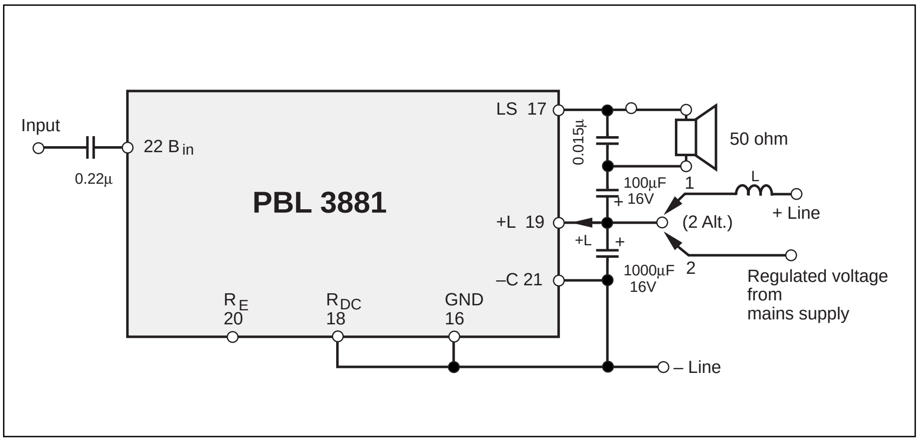


Figure 22. External power supply option. Line supply with inductor or mains supply.

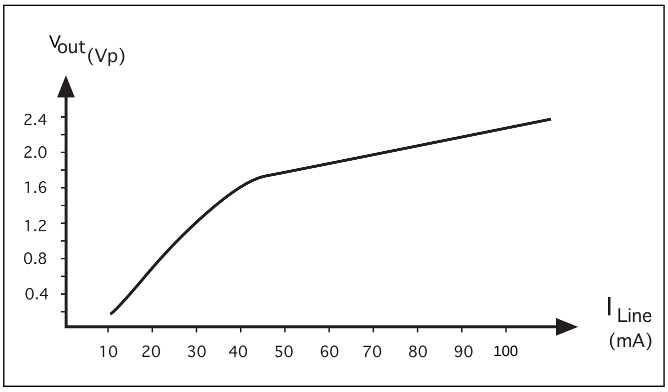


Figure 23. Typical loudspeaker output swing.

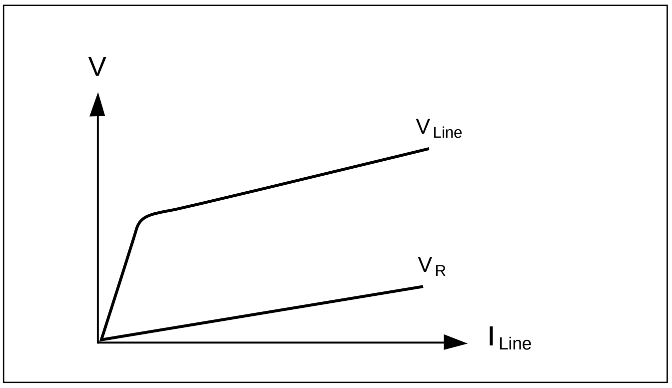
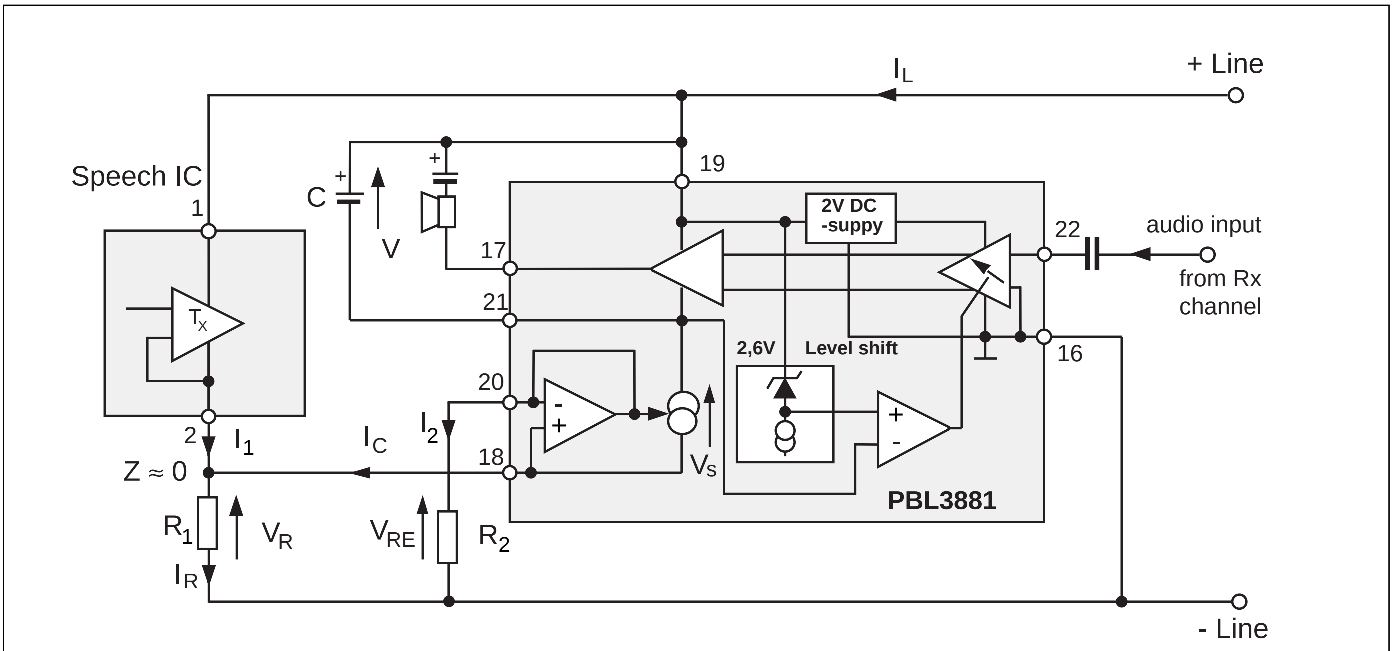


Figure 24. Speech circuit DC characteristics.



$$V_{RE} = V_R \qquad V_R = I_R \times R \qquad I_L = I_R = I_1 + I_C$$

$$V = 0 \text{ then } I_C = 0 \qquad I_C < 50 \times I_2 = 50 \times \frac{V_R}{R_2} = 50 \times \frac{R}{R_2} \times I_R$$

Figure 25. Loudspeaker amplifier current supply system.

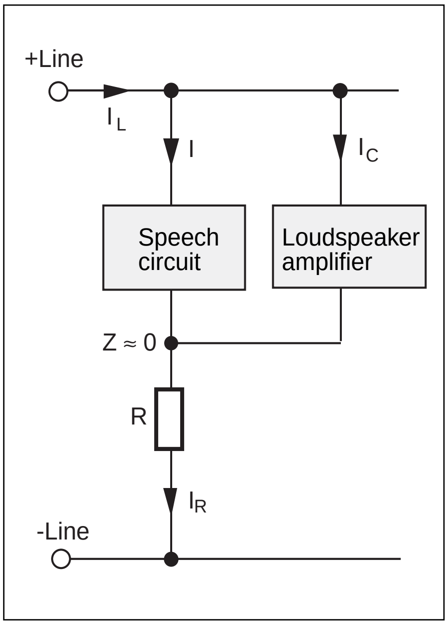


Figure 26. Current sharing system.

transmitting mode periode. The capacitor 220 µF from V_+ via a diode to background noise detector output is to rapid charge the capacitor C_4. This is needed in case the circuit is started in hands free mode, without it the transmitter function would be delayed. See fig.18.

CTR Input

For full speech control (50 dB attenuation between the channels) this input can be left unconnected. To set the function to full ”duplex” (both channels fully open ≈ 0 dB) the input has to be at a level 600 mV below V_+. Intermediate values of speech control attenuation are possible to set within the 600 mV mentioned above. See figures 19 and 20. To set the circuit into a mute state current (35-40 µA) has to be drawn out of the input. By lowering the voltage at the input below 0.9 V a shut down condition will emerge where both receiver and transmitter channels are closed. See fig. 17.

Loudspeaker amplifier

The loudspeaker amplifier drives a 25 - 50 Ω impedance loudspeaker directly. The amplifier is designed to work under a number of different power supply conditions. Fig. 21 and 22. The highest output swing is obtained if pin -C is connected to ground (- Line) and pin +L is connected to a stable DC supply. This supply could be either mains powered or power from the telephone line through an inductor. Fig. 22. Current consumption is directly proportional to the voltage between pins +L and -C. When using the application according to figure 21, pin -C is used as the negative floating supply point for the amplifier. The output signal of the loudspeaker amplifier is referred to +L. The reservoir capacitor C makes it possible for the amplifier to handle power peaks that are much higher than would be possible with continuous signal. The optimal design without using a stable supply is to balance it against the DC characteristics of the speech circuit that is working in parallel. See fig. 25. The single ended loudspeaker amplifier has an internal gain regulation that prevents distortion in case of insufficient line current.

A power amplifier in a handsfree telephone that is supplied from the line.

Comparison between single ended and push-pull output stage.

The amplifier has to have as high efficiency as possible to convert the available line current into audio power. A modern telephone line will give, depending of the line length 20 - 80 mA of current. Standard loudspeaker impedance range, that will come into question, (size, price and availability) is 8 - 50 Ω. The output audio power requirement (electrical) can be 0 - 100mW. The acoustical output power will be greatly dependent of the loudspeaker efficiency. (1 - 15 %)

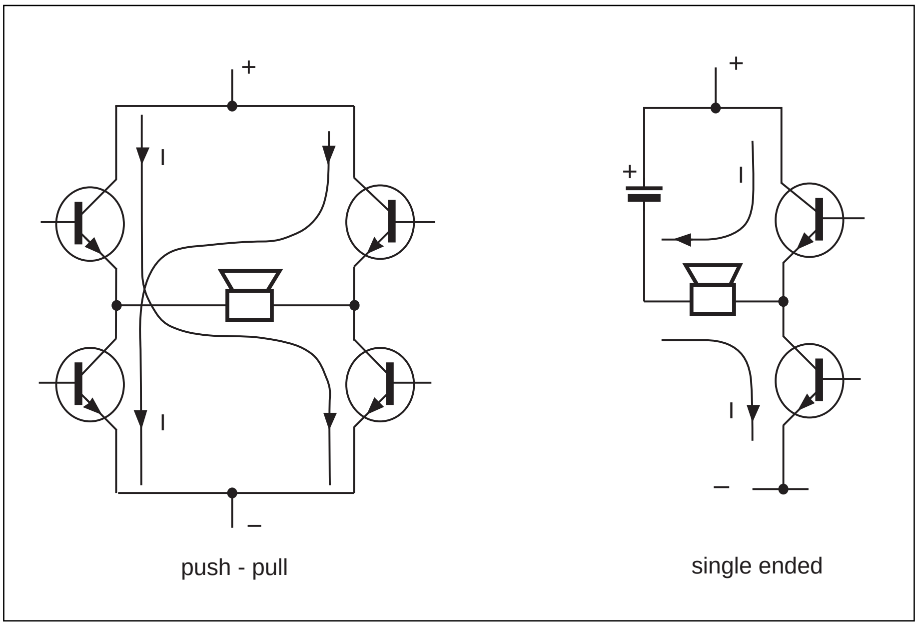


Figure 27. Power amplifier systems.

Example:

How much audio power can be obtained using the PBL 3852 and PBL 3881 in a minimum specification case of 6V/20 mA at the telephone set? Next is to show how much current really is available to drive the loudspeaker.

The current consumption of the speech circuit:

1) 3.4 mA for band gap reference, supply pin 4 and quiscent current for earphone.

2) 2 mA for DC1 that goes to speech switching in the 3881.

3) 6.6 mA for the transmitter, in order to be able to transmit 2 V peak into 300 Ω load (600 Ω/ 600 Ω). DTMF in mute condition.

The current consumption of the handsfree circuit:

1) 2 mA for quiscent current in the power amplifier

2) 2 mA for speech switching (taken into account in speech circuit)

Adding this up leaves only 6 mA to drive the loudspeaker. Luckily this is not the whole truth because the transmitter will not need the whole 6.6 mA in receiver mode when the loudspeaker is used, this will give some 4 mA further to the loudspeaker. From 20 mA line current, 10 mA can be used to drive the speaker.

Assume that a 50 Ω speaker is used, then the power will be $P= I^2 \times R$

0.01 x 0.01 x 50 = 5 mW (not much, but audible) If a 16 Ω speaker would have been used the output would be three times less. The voltage needed for the supply of this is, U = I x R; 0.01 x 50 = 0.5 V. This would be the RMS value of the voltage across the loudspeaker. The voltage across the reservoir capacitor would have to be 2 x 1.41 x 0.5 + (≈0.85) = 2.3 V (0.85 V is the voltage drop across the transistor). The question here is of electrical not acoustical power and the signal used in calculations is a sine wave. In the real working environment the signal will be speech. Peak power for speech that can be taken out of the reservoir capacitor is much higher.

To see how much power can be taken out from a median CO line, it is assumed here that such a line will give 45 mA. As calculated above the speech and handsfree circuits use 10 mA so 35 mA can be used to drive the speaker. The power will be $I^2 \times R$ = 0.035 x 0.035 x 50 = 61.25 mW. The supply voltage needed across the reservoir capacitor is 2 x 1.41 x 0.035 x 50 + 0.85 = 5.8 V.

In this case the DC - mask has to be adjusted as high as possible in order to have enough voltage. The question is if this high output power is desirable or is a satisfactory function at low current levels more important. A solution to this high voltage level in the above example can be halving the loudspeaker impedance but this would of course make the low current function worse.

The rarely observed fact is, that it is the lack of <u>current</u> that limits the availability of power from the telephone line, not the voltage. This means that a single ended A - B class amplifier with hardly any stand by current at all is well suited for the task. This system will render a high efficiency because all the available current will pass the loudspeaker "sort of twice". A push-pull system would be less suitable because it needs double the current in situation like this where availability of current is the limiting factor. This could be overcome by doubling the impedance of the loudspeaker but again that kind of loudspeaker is hardly possible to use (due to price) even if there were some available.

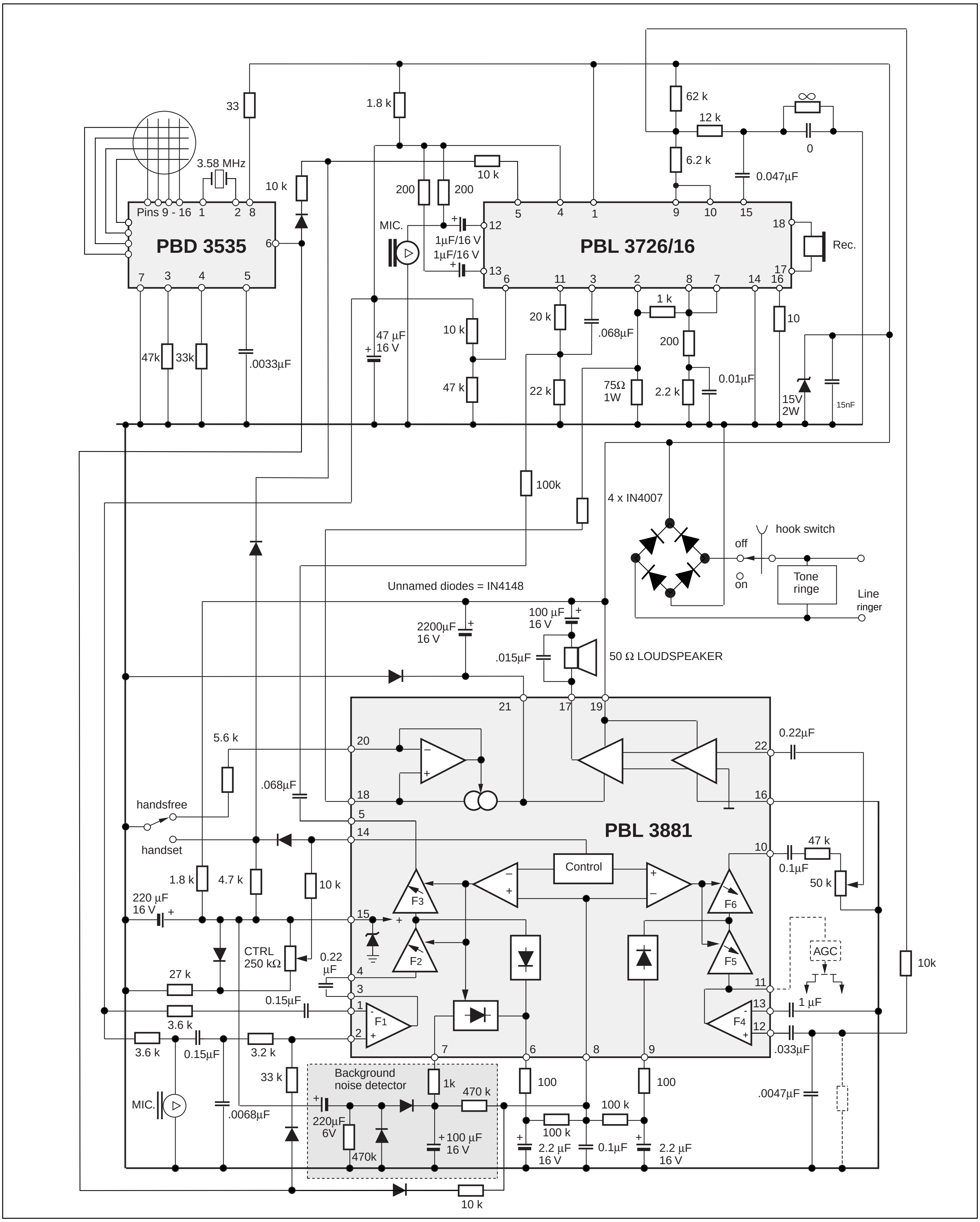


Figure 28. Application 1.

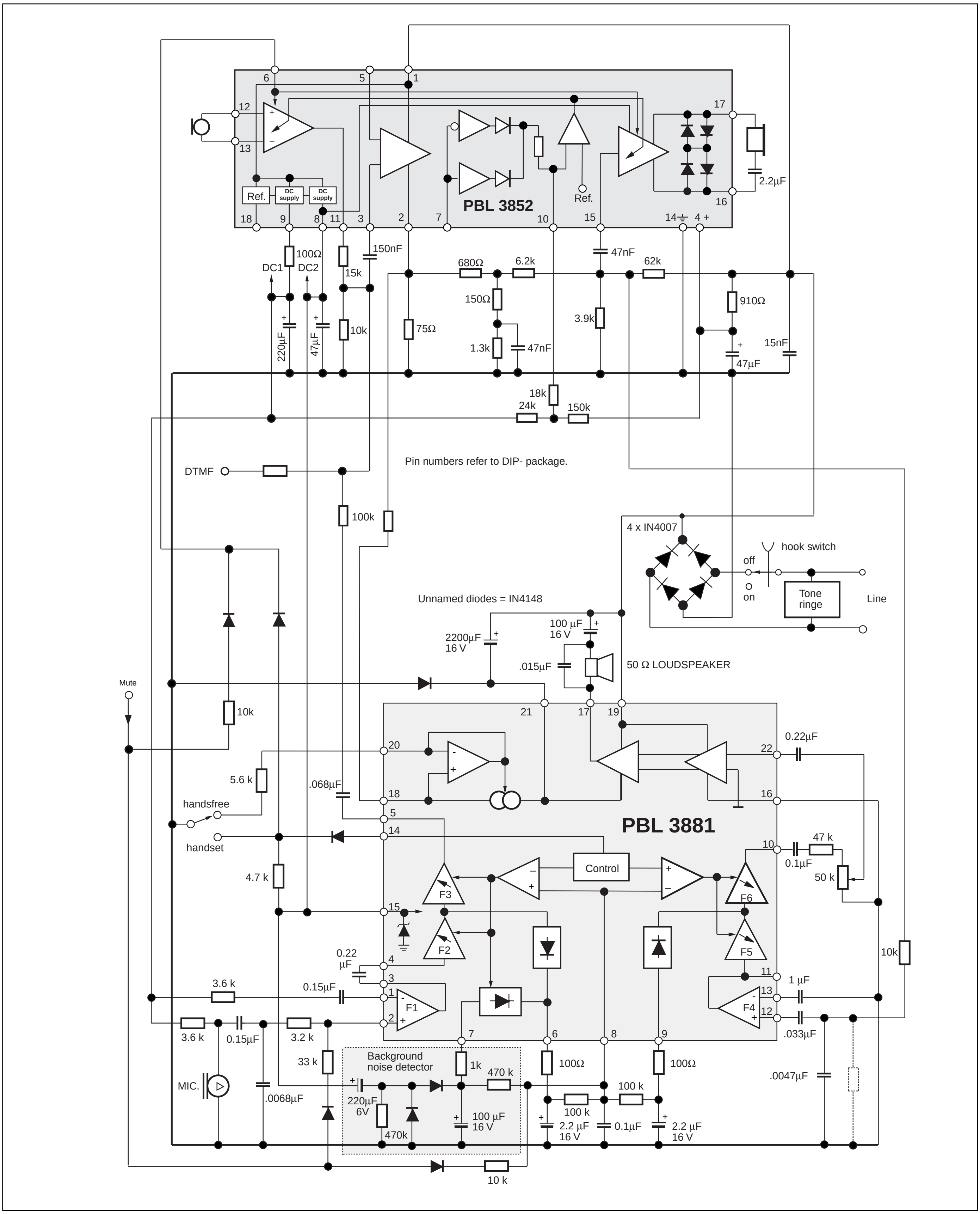


Figure 29. Application 2.

Ordering Information

Package	Temp. Range	Part No.
Plastic DIP	-20 to 70°C	PBL 3881N
Plastic PLCC	-20 to 70°C	PBL 3881SO. 3881SO-T (Tape and reel)
Plastic PLCC	-20 to 70°C	PBL 3881QN. 3881QN-T (Tape and Reel)

IC4 (89007) C-Ue

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