January 1996

PBL 3783 Low Voltage Speech Circuit

Description

The PBL 3783 is a bipolar integrated speech circuit for use in electronic telephones with electret microphones, in telephone line interface in modems, fax-machines or cordless telephones. The circuit is designed to operate at low supply voltages, down to 1.3 V, making it usable when connected in parallel with other telephones.

Compared with the similar circuits PBL 3781 and PBL 3781/02, the transmitting gain has been reduced by 18 dB. This will result in better signal-to-noise ratio when used with electret microphones and other high-level signal sources.

Gain regulation circuitry provides compensation for loop losses in both the transmit and receiver amplifiers.

The receiver amplifier has a balanced push-pull output stage for good driving capabilities of low impedance receivers even at low supply voltages.

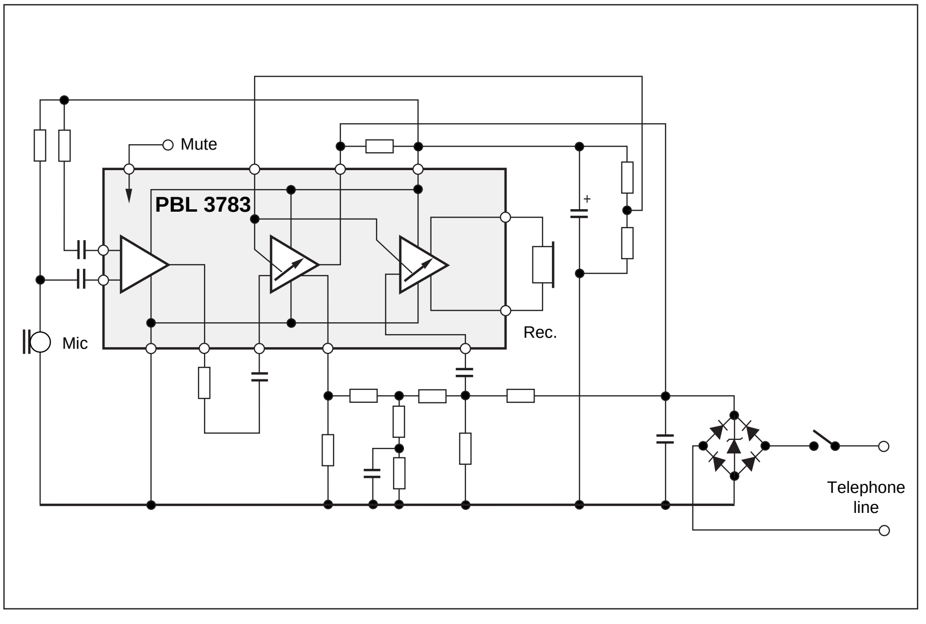
The circuit has a high impedance to the line.

A straight-forward design procedure simplifies adaptation of the circuit to suit different transducers and battery feeding systems.

The pin numbering refers to DIP package.

Key Features

- Low voltage operation, down to 1.3 V DC.
- AC voltage swing down to 0.4 V across the circuit.
- Transmit and receive gain regulation for automatic loop loss compensation. (can be switched off)
- Differential transmitting input.
- Current generator output.
- Balanced receiver output stage.
- The circuit is avaible in two packages 16-pin “batwing” DIP that handles 1.5 W power dissipation and 20 pin SO.



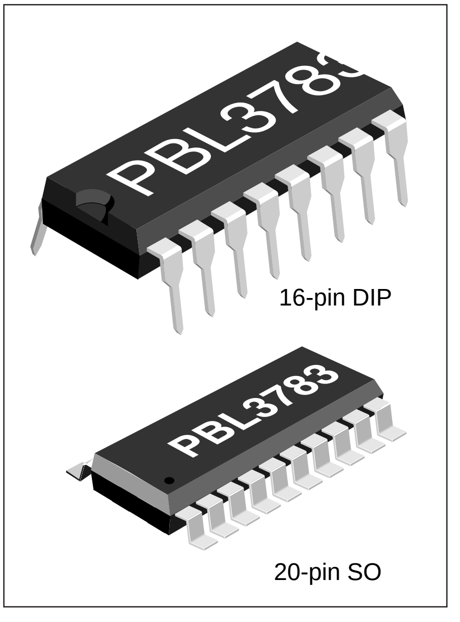


Figure 1. Functional diagram.

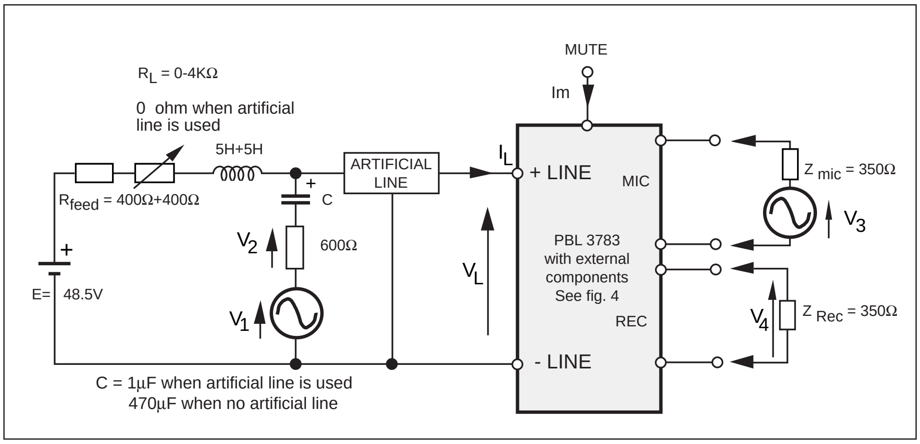


Figure 2. Test setup without rectifier bridge.

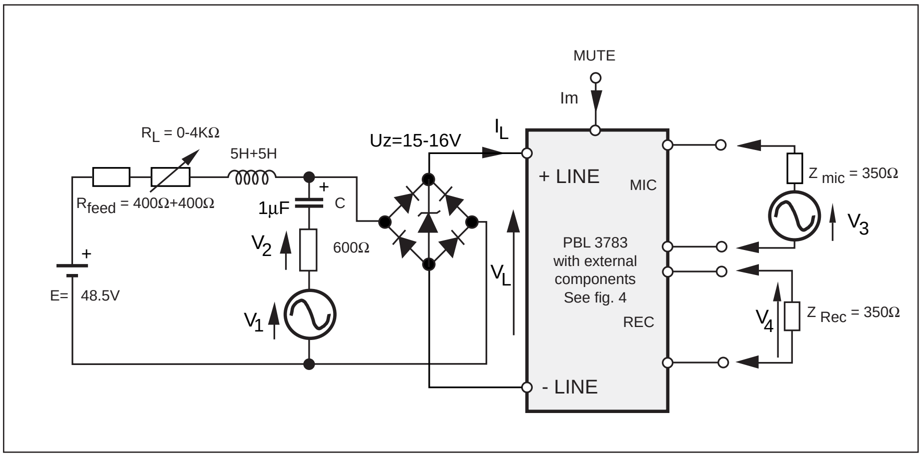


Figure 3. Test setup with rectifier bridge.

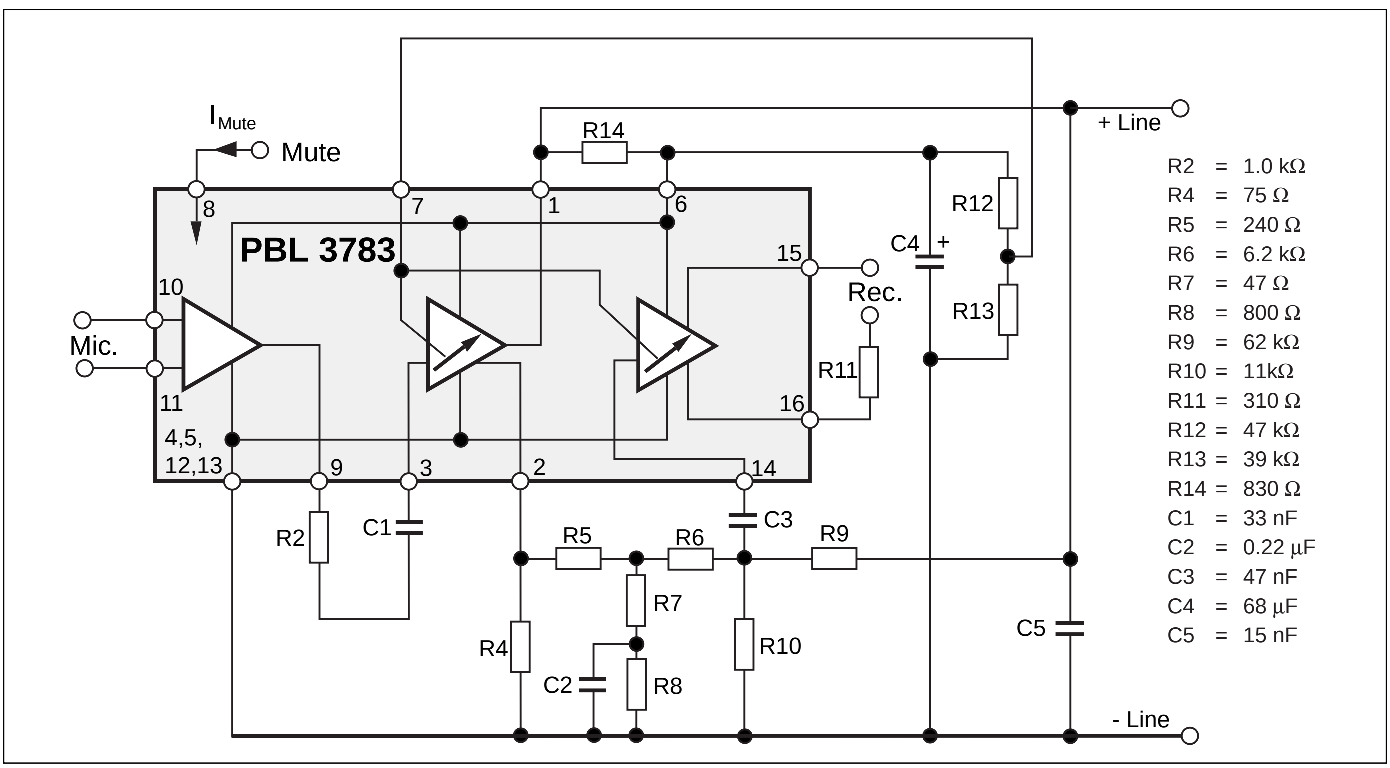


Figure 4. PBL 3783 with external components for test circuits in figures 2 and 3. All pin numbers refer to DIP package.

Maximum Ratings

Parameter	Symbol	Min	Max	Unit
Line current, T_{Amb} = 70 °C				
Dual-in-line package	I_L		150	mA
Small Outline package	I_L		130	mA
Line voltage				
continuous	V_L		15	V
t_p = 2 s	V_L		18	V
t_p = 10 ms	V_L		20	V
Input voltage				
mute	V_{mute}	-0.5	1	V
all other inputs	V_{xx}	-0.5	V_{pin6}+0.5	V
Power dissipation, T_{Amb} = 70 °C				
Dual-in-line package			1.5	W
Small outline package			1.3	W
Operating temperature range	T_{Amb}	-20	+70	°C
Storage temperature range	T_{Stg}	-55	+125	°C

Electrical Characteristics

T_{Amb} = 25 °C . Measured using test circuit of fig. 2 and 3 without artificial cable, unless otherwise noted.

Parameter	Ref. fig.	Conditions	Min	Typ	Max	Unit
DC-characteristics						
Line voltage, V_L		R_4 = 47 Ω				
	2	I_L = 2.5 mA		1.3		V
	2	I_L = 10 mA		3.0		V
	2	I_L = 100 mA		8.5		V
		R_4 = 75 Ω				
	2	I_L = 2.5 mA		1.5		V
	2	I_L = 10 mA		3.2	3.9	V
	2	I_L = 100 mA		11.5	13.6	V
Transmitting gain ,V_2, V_3		20 • ^{10}log (V_2/V_3)				
		f = 1 kHz,				
	2	R_L = 0 Ω	34	36	38	dB
	2	R_L = 400 Ω	38	40	42	dB
	2	R_L = 900 Ω	41	43	45	dB
Transmitting gain, range of regulation	2	f = 1 kHz , R_L = 0 to 900 Ω	5	7	9	dB
Transmitting frequency response	2	200-3400 Hz	-1		+1	dB
Receiving gain,V_4, V_1		20 • ^{10}log (V_4/V_1)				
		f = 1 kHz, (Adjustable with R_{10})				
	2	R_L = 0 Ω	-18.5	-16.5	-14.5	dB
	2	R_L = 400 Ω	-16	-14	-12	dB
	2	R_L = 900 Ω	-13.5	-11.5	-9.5	dB
Receiving gain range of regulation	2	f = 1 kHz, R_L = 0 to 900 Ω	3	5	7	dB
Receiving frequency response	2	200-3400 Hz	-1		+1	dB
Input impedance microphone amplifier	2,4	f = 1 kHz		2.5		kΩ
Transmitter dynamic output level, V_2	7	200-3400 Hz, THD ≤ 2.5 %, I_L = 20-100 mA		1.5		V_{Peak}
Transmitter maximum output level, V_2	7	200-3400 Hz, I_L = 0-100 mA, V_3 = 0-1 V				
		limit that can not be exceeded		3.5		V_{Peak}
Receiver output impedance	2, 4	f= 1 kHz (see note)		6 (+310)		Ω
Receiver dynamic output level , V_4	2	200-3400 Hz, THD ≤ 2 %, I_L = 20-100 mA		0.5		V_{Peak}
Receiver maximum output level,V_4	3	200-3400 Hz, I_L = 0-100 mA, V_1 = 0-50 V				
		limit that can not exceeded		1		V_{Peak}

Parameter	Ref fig	Conditions	Min	Typ	Max	Unit
Transmitter noise level, V_2	2	Psophometric weighted relative to 1 V_{rms}, R_L = 0		-78		dB_{psofh}
Receiver noise level,V_4	2	A-weighted, relative to 1 V_{rms}, with artificial cable: 0-5 km , Ø = 0.5 mm 0-3 km, Ø = 0.4 mm		-83		dB_A
DC current generator output I_O (zero at mute)	5	Pins 10 and 11 to pin 6 I_L = 10-150 mA, DC-current at pin 9	500			μA
Mute current, I_{Mute}	4	I_L = 10-150 mA	100			μA

Note: External resistor in the test setup.

Warning: It is important not to use a receiver that is too sensitive. Otherwise the internal clipping will not function properly, and possible acoustic shocks may cause permanent damage to the human ear.

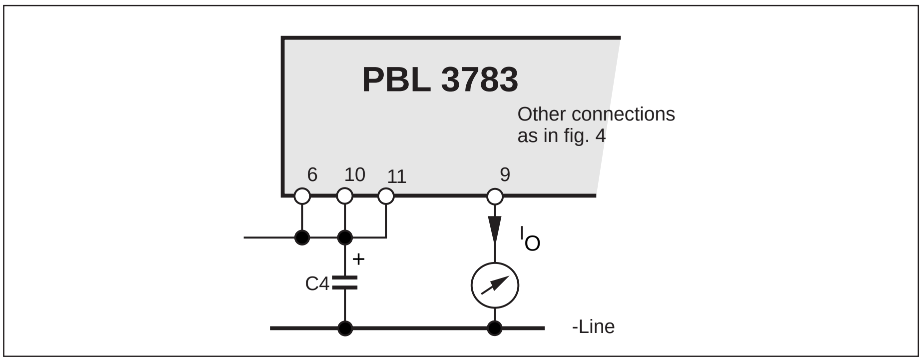


Figure 5. DC-current generator.

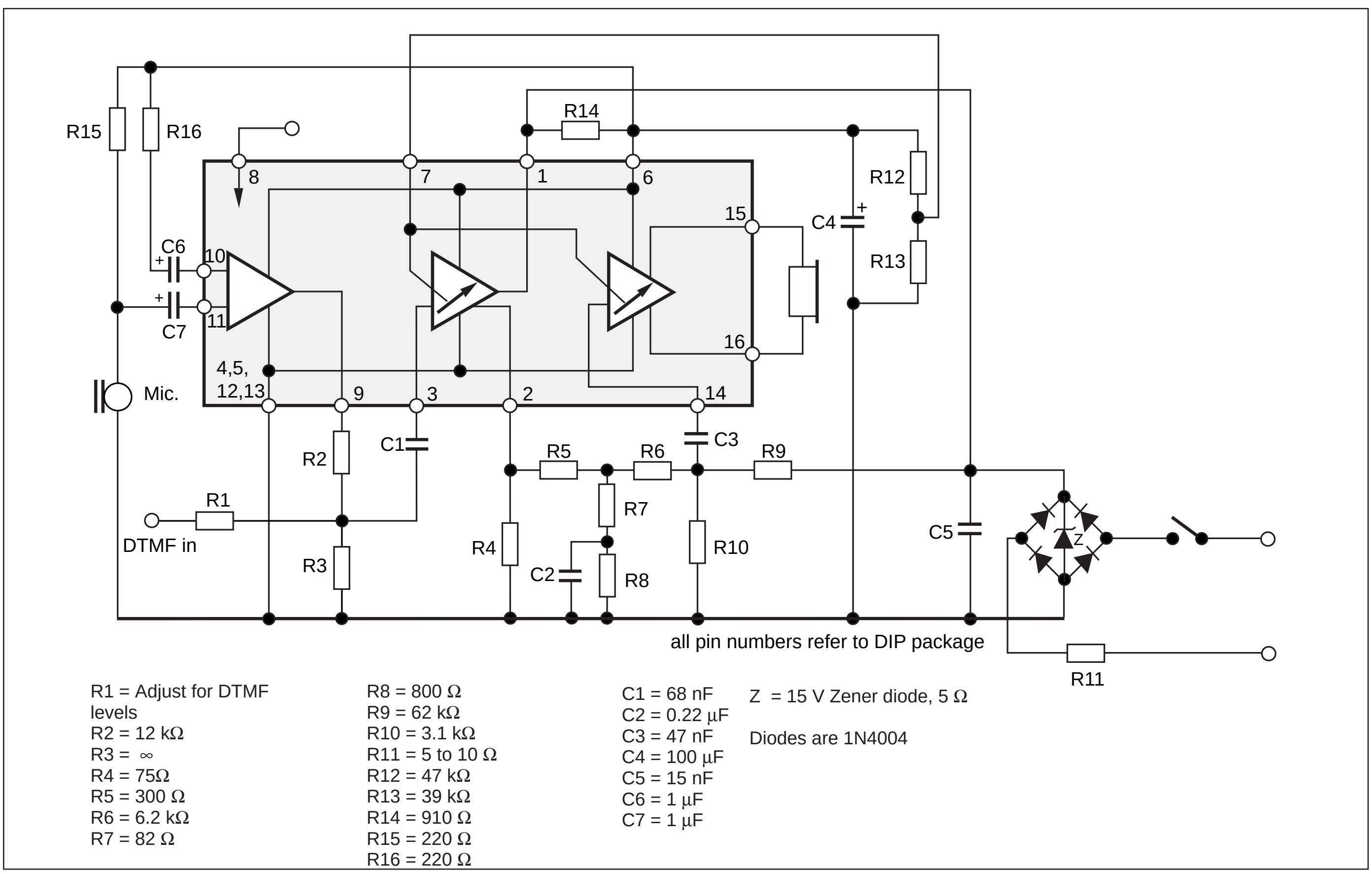


Figure 6. Basic application for 48V/2 X 400 ohms battery feeding system and electret microphone and dynamic receiver.

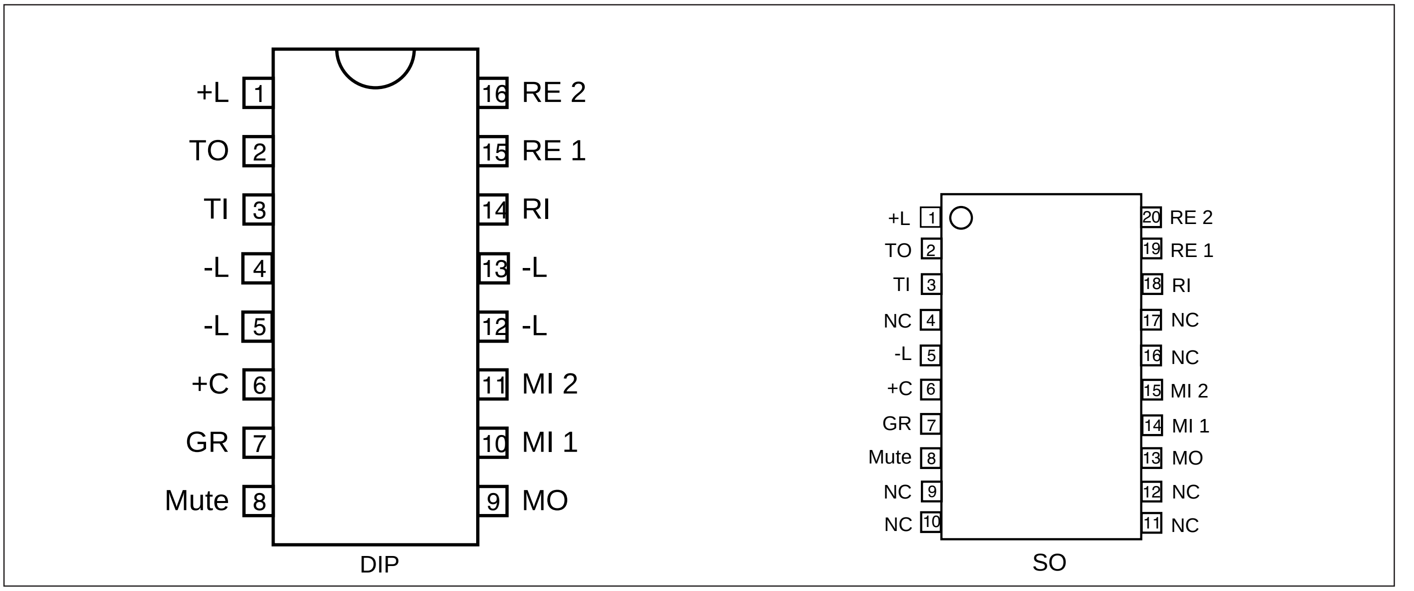


Figure 7. Pin configuration.

Pin Descriptions

Ref. fig 3 and 5.

DIP	SO	Name	Description
1	1	+ L	Output of the DC-regulator and transmit amplifier. This pin is connected to the line through a polarity guard diode bridge.
2	2	TO	Output of the transmit amplifier. This pin is connected via a resistor R4 of 47 - 75 ohms to -L. It sets the DC series-resistance of the circuit. The output has a low AC impedance, and the signal is used to drive a sidetone balancing network R5, R7, R8 and C2.
3	3	TI	Input of the transmit amplifier. Input impedance varies from 65 kΩ±20% at short line length to 45kΩ±20% at long line length.
4, 5, 12,13	5	-L	The negative line terminal, connected to the line through a polarity guard diode bridge.
6	6	+C	Positive power supply terminal for most of the circuitry inside the PBL 3783 (about 1 mA const. current). The majority of the line current however, passes through the TO and +L pins (see above). The +C pin is connected to a decoupling capacitor, C4 of 47 - 150 uF.
7	7	GR	Control input for the gain regulation circuitry.
8	8	MUTE	MUTE input that requires min. 100 µA, to mute the microphone and receiver amplifiers.
9	13	MO	Output of the microphone amplifier. When the microphone amplifier is not used, this pin can be connected as a current generator output. See functional description for pins 10 and 11 below.
10 11	14 15	MI1 MI2	Inputs of the microphone amplifier. The input impedance at these pins is approx, 2.5 kohms. Connecting pins 10 and 11 to pin 6, (+C) switches pin 9 (MO) into a current generator output, that sources about 500 µA.
14	18	RI	Input of receiver amplifier. Input impedance is approx. 35 kohms.
15,16	19, 20	RE1, RE2	Receiver amplifier output. The output is intended to drive low impedance receivers.
	4, 9, 10,		Not connected.
	11, 12,		Not connected.
	16, 17		Not connected.

Functional Description

The PBL 3783 contains a DC-regulator, a microphone amplifier, a transmit amplifier and a receiver amplifier.

The DC-regulator determines the voltage/current characteristics of the circuit. Looking from the line, the circuit acts as a reference voltage of approx. 2.5 Volts in series with a resistor (externally set). The voltage reference is derived from a bandgap reference, which provides for temperature-stable DC-characteristics. To maintain operation even when the line voltage (inside polarity guard diode bridge) drops below 2.5 Volts, the circuit automatically changes to a lower reference voltage.

A microphone amplifier with a differential input stage, and hence good common mode rejection, is provided for electret microphones.

The transmit amplifier receives its input signal from the microphone amplifier. The transmit output stage contains the previously described DC-regulator. The AC-gain is regulated with the line length (selectable), and the output level is amplitude limited to eliminate sidetone distortion at high transmitting levels.

The sidetone cancellation (hybrid function) works as follows: A signal, opposite in phase from the transmit signal on the line, is taken from the transmit amplifier and fed through a sidetone balancing network into the summing junction of the receiver amplifier. The signal from the line is added, and sidetone cancellation occurs. Only the receive signal, is left at the input of the receiver amplifier.

The AC-gain of the receiver amplifier is regulated with the line length. The output from the receiver amplifier is intended to drive low-impedance receivers. An internal clipping network limits the signal to the earphone, and prevents acoustic shocks.

Applications Information

The PBL 3783 is a flexible circuit designed to meet specifications from telephone administrations all over the world. Adaptation to different battery feeding systems and transducers is made by selecting the values of few external components.
Figure 6 shows the PBL 3783 and associated components in a basic telephone speech network. To complete an electronic telephone, the circuit needs to be supplemented with a tone ringer and a DTMF and/or pulse dialler circuit.

When proceeding through a design, some of the circuit adjustments will interact with each other. It is therefore recommended to adjust the parameters in the following order:

1. Impedance to the line.
2. DC-characteristics.
3. Microphone selection, transmitting gain and frequency response.
4. Gain regulation.
5. Side-tone level, receiving gain and frequency response.

Impedance to the line

The output impedance of the circuit is determined by R14 in parallel with C5. R14 is normally set to a value between 600 and 900 ohms to satisfy the return loss requirements. R14 also supplies the operating current for the circuit functions.

It is recommended to select a value near 900 ohms, in order to maximize the available output level from the transmit amplifier. A lower value of R14 requires a larger capacitor C4 for the stabilization of the supply voltage at pin 6. C5 should be located near the circuit to effectively suppress any radio interference pick-up.

DC-characteristics

The DC-behavior is adjusted by resistor R4, which determines the slope of the V-I curve. For line currents above 10 mA, the circuit acts as a series combination of R4 and a zenar diode of approx 2.5 volts.

The minimum working voltage is approximately 1.3 volts, which corresponds to about 2.5 mA line current with R4=47 ohms.

R4 should be selected to give a safe operating point at very short loops. A low value results in excessive current through the circuit and too low signal level for sidestone balancing, while a larger resistance may raise the voltage above the rated maximum. Suitable values of R4 ranges from 47 to 75 ohms depending on the battery feeding system.

Microphone selection, transmitting gain and frequency response

The microphone amplifier section is intended for electret microphones and provides about 26 dB voltage gain. A differential input stage (pins 10 and 11) gives a good common mode rejection.

Capacitor C1 is inserted to give a low-frequency cut-off in the transmit path. The external impedance at pin 3 should be ≤10 kΩ otherwise it can influence the transmitter gain regulation curve.

The transmit amplifier has a current generator output which means that the voltage gain is partly determined by the ratio between R14 in parallel with the line impedance and R4. The voltage gain from the input at pin 3 to the output (pin 1) varies approximately between 16 and 23 dB over the regulation range with R14 = 900 ohms, R4=47 ohms and a line impedance of 600 ohms.

Gain regulation

Automatic gain regulation circuitry in the transmit and receiver amplifiers controls the gain with the loop length, see figure 8. The control voltage for the gain regulation is fed into pin 7. By changing the resistive attenuator consisting of R12 and R13, it is possible to shift the location of the regulation curve to get a correct compensation in different battery feeding systems. The slope of the curve is determined by R4. Gain regulation can be cut off completely by tying pin 7 to ground (pin 4, 5, 12, 13) for high gain.

Side-tone level, receiving gain and frequency response

Side-tone cancellation occurs at the input of the receiver amplifier (pin 14) which receives opposite-phased transmit signals from the line and the side-tone network respectively.

Resistor R5 and the actual balancing network consisting of R7, R8 and C2, simulates a first order approximation of the output impedance of the circuit and the line impedance. A practical sequence for determining the component values in

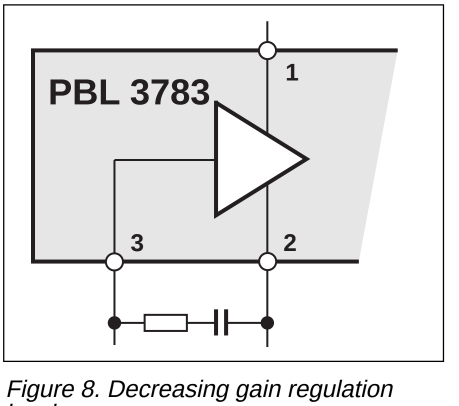
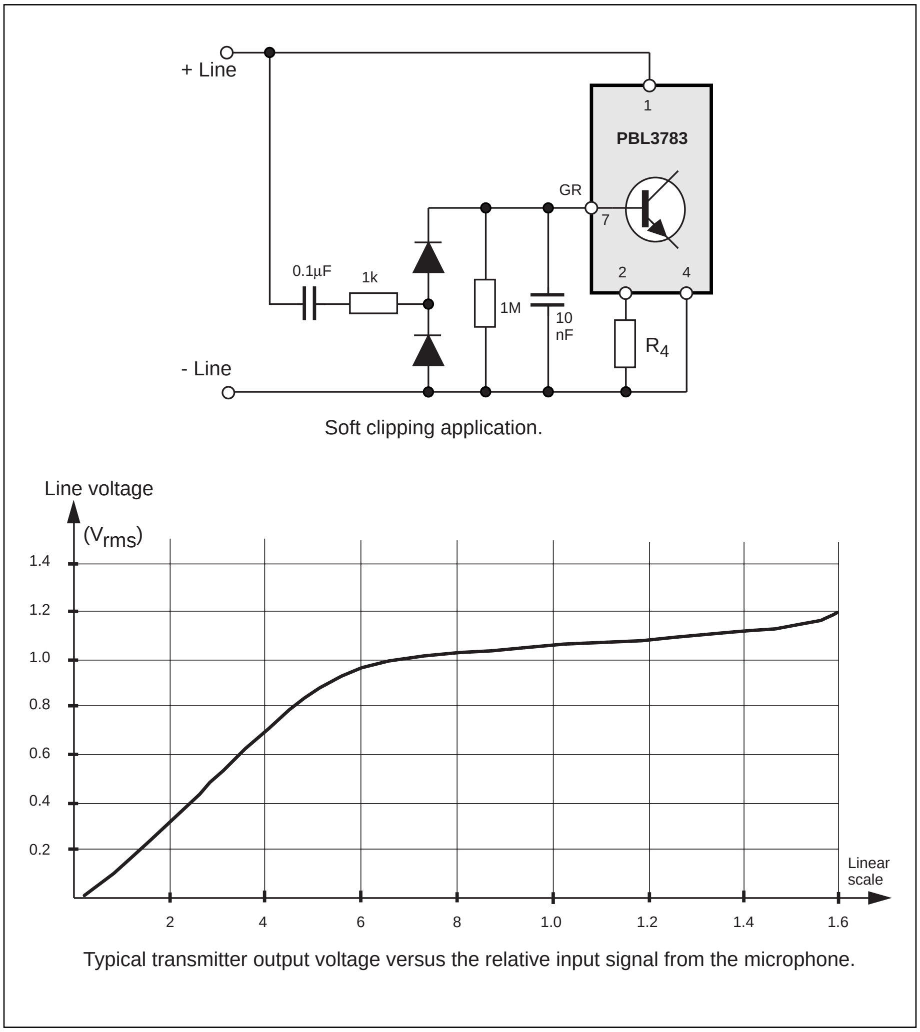


Figure 8. Decreasing gain regulation level.



Soft clipping application.

Typical transmitter output voltage versus the relative input signal from the microphone.

Figure 9. Soft clipping.

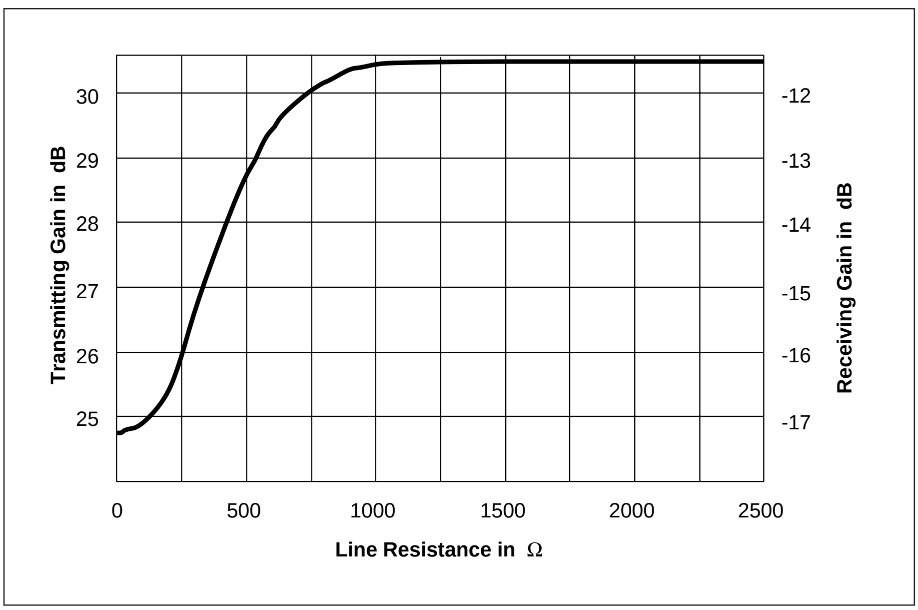


Figure 10. Typical gain regulation curve.

the side-tone network is given below. Observe that some iterations and experimental work has to be carried out to find an optimum solution.

1. The value of R5, choose two to four times the value of R4.
2. R7, R8 and C2 should simulate the amplitude and phase response of the line impedance seen at the line terminals. The impedance level of the balancing network should be about one tenth of the line impedance. The values given in figure 6 is a good starting point in most cases.
3. The ratio between R6 and R9 should be set to make the signals coming from the line and from the side-tone network equal in amplitude so that cancellation occurs. The value of R6 should be about an order of magnitude larger than the impedance level of the balancing network.
4. R10 is selected to give the desired receiving gain.
5. Steps 2 to 4 (change R7, R8, C2) above may have to be repeated to give the required side-tone level and receiving gain.

The coupling capacitor C3 is needed for low-frequency cut-off in the receiving amplifier. The input impedance at pin 14 is approximately 35 kohms. A balanced push-pull output stage provides good driving capabilities even at low supply voltages. The circuit is intended to drive low-impedance receivers. High-inductance magnetic transducers may require a series resistor to define a correct driving impedance.

Internal clamping diodes in the output stage prevent excessive acoustic levels which may cause damage to the listener's ear.

Transmit level low distortion dynamic limiting ("soft clipping").

The circuit diagram in fig. 9. shows a method to implement Peak Line Signal Level Control with low distortion, also called "soft clipping". The purpose of the circuitry is to reduce the risk of distortion that may occur if the line level is too high, in combination with excessive transmitting gain due to a high line impedance.

The fast attack, slow decay circuitry make use of the Gain Regulation input of the PBL 3783 to limit the line output signal level. Typical limiting characteristics is shown in fig. 9.

Ordering Information

Package	Temp. Range	Part No.
Plastic DIP	-20 to + 70°C	PBL 3783N
Plastic	-20 to + 70°C	PBL 3783SO
Plastic	-20 to + 70°C	PBL 3783SO-T

Specifications subject to change without notice.
IC4 (94028) B-Ue

Ericsson Components AB
S-164 81 Kista-Stockholm, Sweden
Telephone: (08) 757 50 00