

Uppgjord - Prepared M/TI2 G Engström	Tekn. ansv. - Technical responsible M/TI2C	Nr - No 120 PBL 3726/16N
Dokansv/Godk - Doc respons/Approved M/TO	Granskad - Checked M/TI2C	Datum - Date 1987-10-08
		Rev A
		File PBL372616N.120

Sheet      2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19  
Rev.        A A A A A A A A A A A A A A A A A A A

### TRANSMISSION CIRCUIT

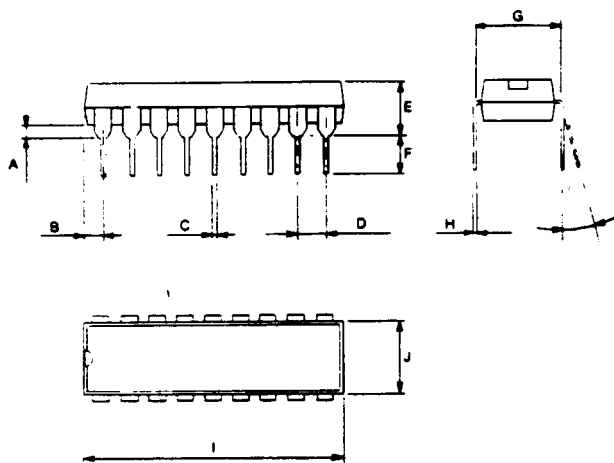
#### GENERAL INFORMATION

The circuit is designed to form a part of the transmission function in a telephone set.

The input of the transmitting amplifier is designed to be used together with a low impedance microphone. The gain of the transmitter and receiver amplifier is regulated and increases with line length. Mute input is included. An extra amplification stage is included in the circuit. Push-button controlled cut-off of the transmitting amplifier is available. The gain regulation is set with external components. The receiver output driving capability is adjustable. Extended current and voltage range (5 - 130mA, down to 2V).

#### MECHANICAL DATA

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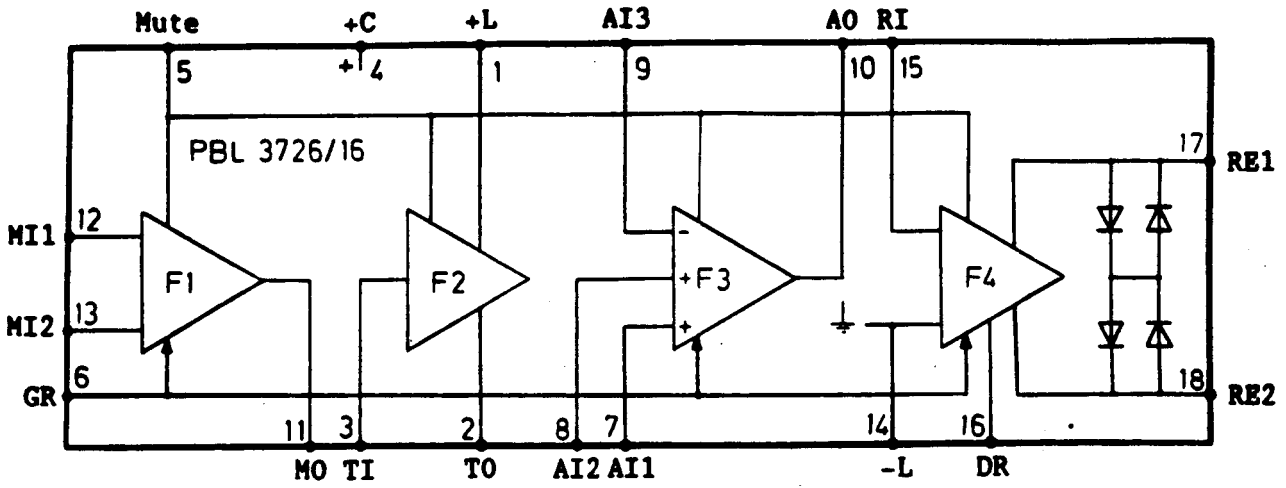
	Inch		Millimeter	
	Min	Max	Min	Max
A	.020	.060	0.51	1.52
B	.035	.065	0.89	1.65
C	.015	.023	0.38	0.58
D	.090	.110	2.29	2.79
E	.150	.200	3.81	5.08
F	.100	.180	2.54	4.57
G	.290	.310	7.37	7.87
H	.008	.014	0.20	0.36
I	.870	.930	22.10	23.62
J	.220	.280	5.59	7.11

#### Design

Integrated circuit in plastic DIL package with 18 tinned leads.

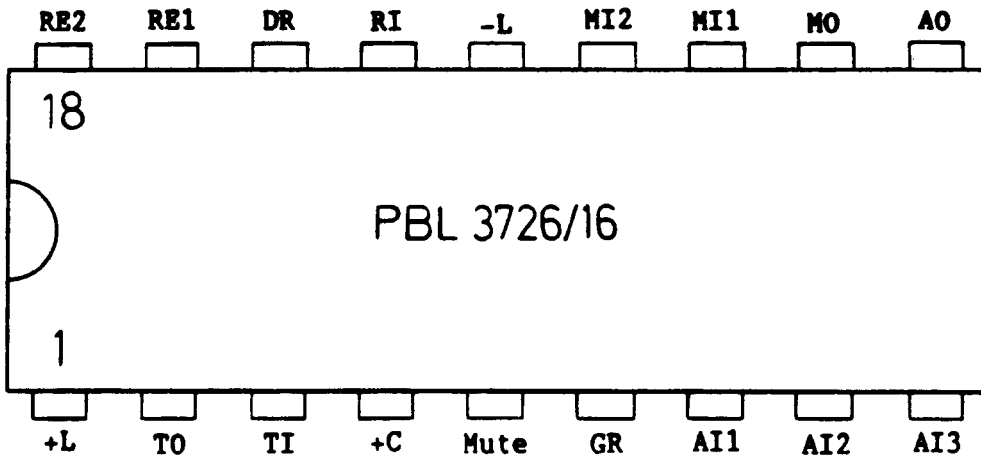
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**FUNCTIONAL DIAGRAM**



**PIN CONFIGURATION**

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**PIN DESCRIPTION**

Pin	Name	Function
1	+L	Output of the DC-regulator and transmit amplifier. This pin is connected to the line through a polarity guard diode bridge.
2	TO	Output of the transmit amplifier. This pin is connected through a resistor of 47 to 100Ω to -L, which in practice sets the DC-resistance of the circuit. The output has a low AC-output impedance and the signal is used to drive a side-tone balancing network.
3	TI	Input of transmit amplifier. Input impedance 17kΩ ±20%.
4	+C	This pin is the positive power supply terminal for most of the circuitry inside the PBL 3726/16 (about 1mA current consumption). The +C pin should be connected to a decoupling capacitor of 47 to 150μF to ground and a resistor to +L.
5	Mute	The mute input which requires minimum 100μA source to mute the microphone and receiver amplifiers.
6	GR	This pin is the control input for the gain regulation circuitry.
7	AI1	These pins are positive inputs to a line length controlled separate amplifier (F <sub>3</sub> ) where at short lines pin 7 is active and at long lines pin 8 is active. Going from short lines to long lines input pin 7 is deactivated and input pin 8 is activated in a continuous way. When pin 8 and 7 are directly connected to each other the amplifier is line length independent.
8	AI2	
9	AI3	This pin is a line length independent negative input to the separate amplifier (F <sub>3</sub> ).
10	A0	This pin is the output of the separate amplifier (F <sub>3</sub> ).
11	MO	Output of the microphone amplifier.
12	MI1	Input to the microphone amplifier.
13	MI2	Input impedance 1.7kΩ ±20%
14	-L	The negative power terminal, connected to the line through a polarity guard diode bridge.
15	RI	Input of the receiver. Input impedance is approximately 38kΩ ±20%.
16	DR	This pin is the control input for the receiver amplifier driving capability.
17	RE1	Receiver amplifier outputs. Output impedance approximately 3Ω.
18	RE2	

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**MAXIMUM RATINGS**

Parameter	Min	Max	Units
Line voltage $t_p = 2$ sec		22	V
Continuous operating line current		130	mA
Operating temperature range	-20	70	°C
Storage temperature range	-55	125	°C

**CHARACTERISTICAL DATA** $T_{amb} = 25^\circ\text{C}$ 

Parameter	Ref. Conditions fig.	Min	Typ	Max	Units
Terminal voltage	1 $I_{DC} = 15$ mA	3.3	3.7	4.1	V
	1 $I_{DC} = 100$ mA	11	13	15	V
Transmitting gain *	$20 \cdot 10 \log \left( \frac{U_2}{U_3} \right); 1$ kHz				
	1 $R_L = 0$	41	43	45	dB
	1 $R_L = 400 \Omega$	43.5	45.5	47.5	dB
	1 $R_L = 900 \Omega - 2.2$ k $\Omega$	46	48	50	dB
Transmitting range of regulation	1 1 kHz $R_L = 0 \Omega - 900 \Omega$	3	5	7	dB
Transmitting frequency response	1 200 Hz - 3.4 kHz	-1		1	dB
Receiving gain *	$20 \cdot 10 \log \left( \frac{U_4}{U_1} \right); 1$ kHz				
	1 $R_L = 0 \Omega$	-18.5	-16.5	-14.5	dB
	1 $R_L = 400 \Omega$	-16	-14	-12	dB
	1 $R_L = 900 \Omega - 2.2$ k $\Omega$	-13.5	-11.5	-9.5	dB
Receiving range of regulation	1 1 kHz $R_L 0 \Omega - 900 \Omega$	3	5	7	dB
Receiving frequency response	1 200 Hz - 3.4 kHz	-1		1	dB

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**CHARACTERISTICAL DATA (cont.)**

Parameter	Ref. Conditions fig.	Min	Typ	Max	Units
Transmitter input impedance	1 1 kHz		1.7(//2.7) ***		k $\Omega$
Transmitter dynamic output voltage	1 200 Hz - 3.4 kHz $\leq$ 2% distortion $I_{DC} = 20 - 100$ mA		1.5		V <sub>p</sub>
Transmitter max output voltage	1 200 Hz - 3.4 kHz $U_3 = 0 - 1$ V $I_{DC} = 0 - 100$ mA		3		V <sub>p</sub>
Receiver output impedance	1 1 kHz		3 (+310) ***		$\Omega$
Receiver dynamic output voltage	** 1 200 Hz - 3.4 kHz $\leq$ 2% distortion $I_{DC} = 20 - 100$ mA		0.5		V <sub>p</sub>
Receiver max output voltage	2 Measured with rectifier 200 Hz - 3.4 kHz $I_{DC} = 0 - 100$ mA $U_1 = 0 - 50$ V		0.9		V <sub>p</sub>
Transmitter output noise	1 $P_{soph}$ -weighting, rel 1 V, $R_L = 0 \Omega$		-75		dB <sub><math>P_{soph}</math></sub>
Receiver output noise	1 A-weighting, rel 1V with cable: 0 - 5 km $\phi$ 0.5 mm 0 - 3 km $\phi$ 0.4 mm		-85		dB <sub>A</sub>
Mute input current	1	0.1			mA
Extra available current when muted at the same DC-voltage	1 $I_{DC} = 15 - 100$ mA		10		mA

\* Adjustable to both higher and lower values with external components.

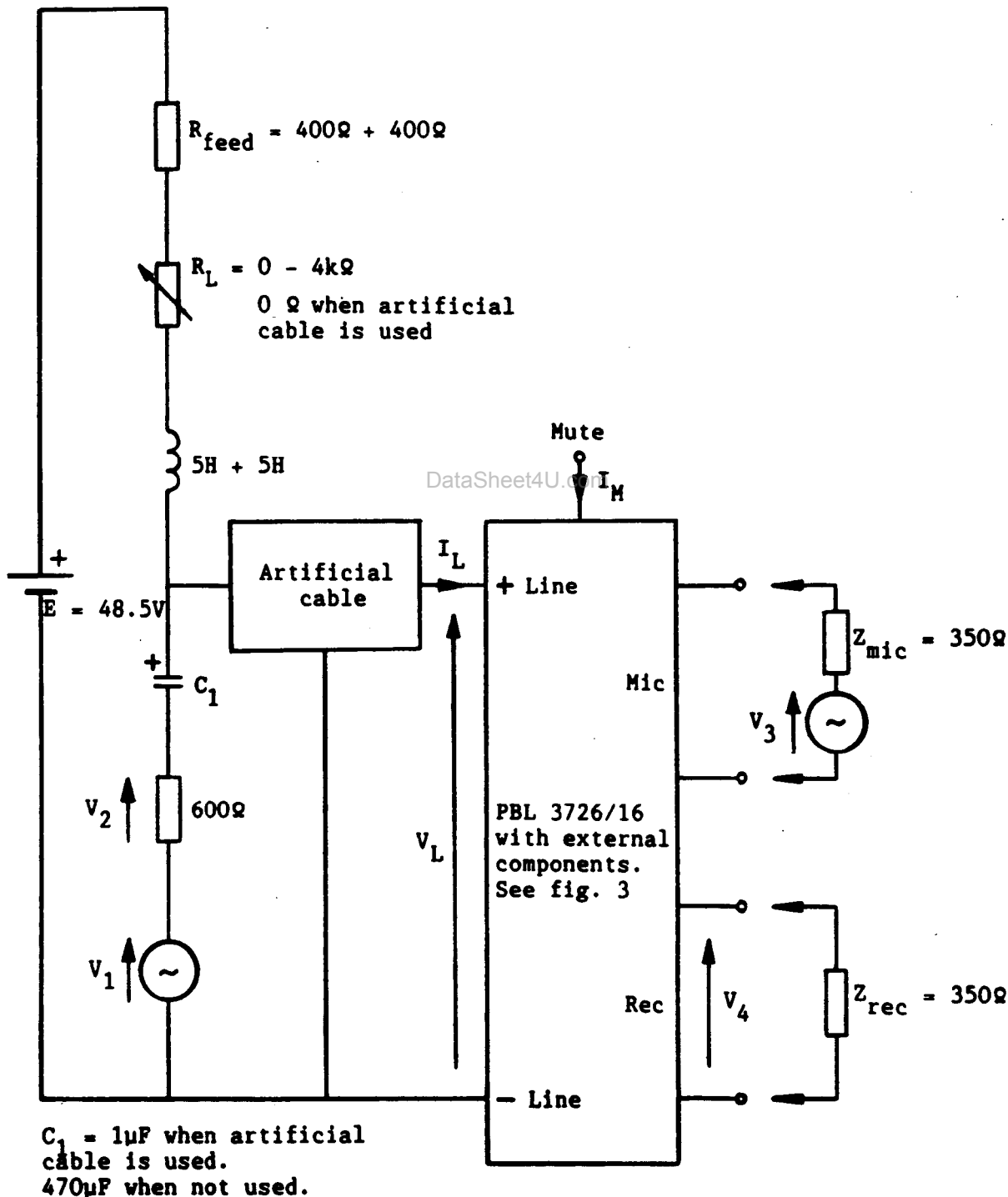
\*\* The dynamic output can be doubled. See application notes.

\*\*\* External resistor in test setup.

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**FIG 1**

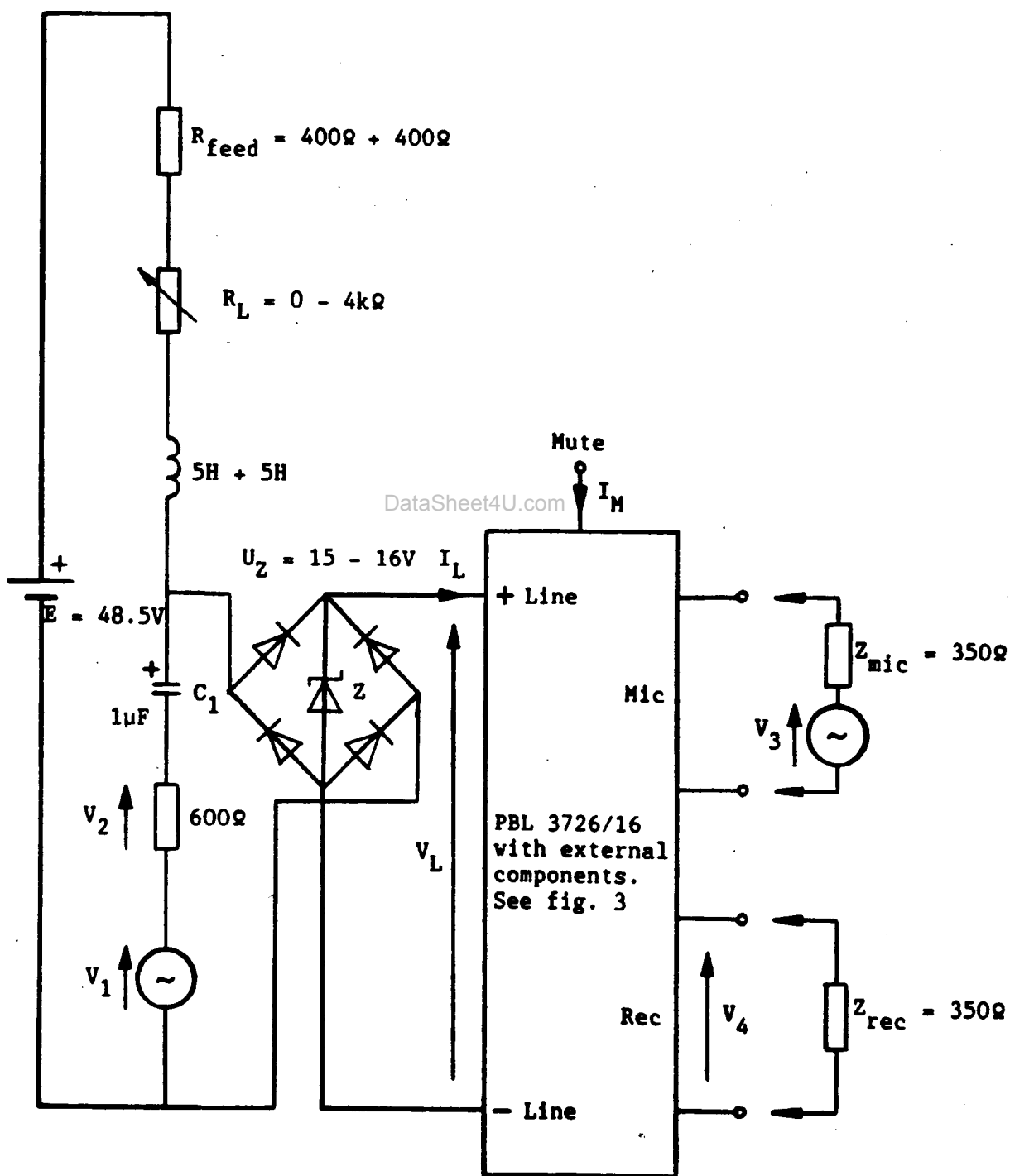
### Test set up without rectifier bridge



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**FIG 2**

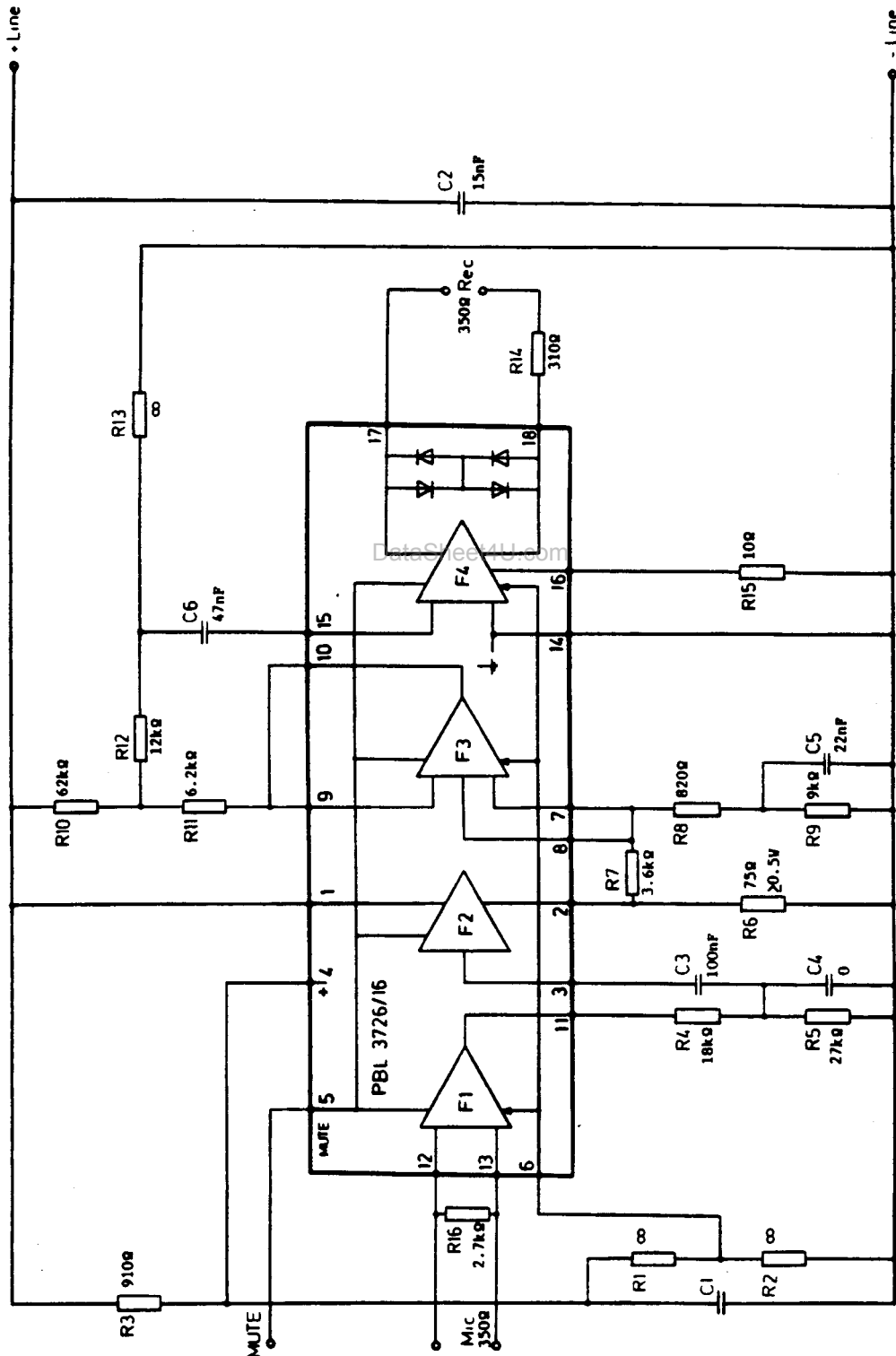
Test set up with rectifier bridge



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**FIG 3**

PBL 3726/16 with external components for test set up. See fig 1.





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**FUNCTIONAL DESCRIPTION**

The gain of the transmitting and receiving amplifiers are continuously and equally changed with the line length. The start point for the gain regulation is externally set. The gain regulation can be cut-off externally, and the gain can then be set to be the gain used for either long or short lines.

The outputs of the transmitting and receiving amplifiers have internal limitations of the output amplitudes.

The circuit includes a temperature independent voltage reference used for regulation of the DC line current and for regulation of the transmitting and receiving gain. The DC voltage is very fast settled to its final value with a minimum of overshoot.

The circuit uses a minimum of external components. In a normal practical case only five external capacitors of which only one is an electrolytic/tantalum filter capacitor. The other capacitors are needed as radio interference suppression capacitor over the line, one capacitor in the side-tone balancing network and one capacitor each for low frequency cut-off in the transmitting and receiving amplifiers. The frequency response is, except for that, flat for both amplifiers.

The circuit will with external components have a very good return loss behaviour, both against purely resistive lines as for instance 600  $\Omega$  and against complex networks as 900  $\Omega$  in parallel with 30 nF.

To get a good CMRR the microphone input is balanced.

It is possible to add a push-button controlled cut-off of the transmitting amplifier to the circuit without any disturbance of the other circuit functions.

A mute input is included in the circuit.

It gives:

- 1) Cut-off of the transmitting amplifier ( $F_1$ ).
- 2) Reduced unregulated gain in the receiving amplifier.
- 3) Power down to reduce the current consumption.

When a mute signal is applied on the circuit it reduces its power consumption and adjusts the DC regulation accordingly. This makes it possible to use a DTMF generator like RIFA's PBD 3535 or PBD 3552 and still have the same DC behaviour when you are dialling.

The receiver amplifier is equipped with a high impedance input stage. This gives a less expensive RC network on the input.

Only resistive elements are used to set the receiving gain.

A push-pull power stage in the receiving amplifier gives a high output swing.

To get the extended low current and voltage range two resistors have to be connected from microphone input to ground.

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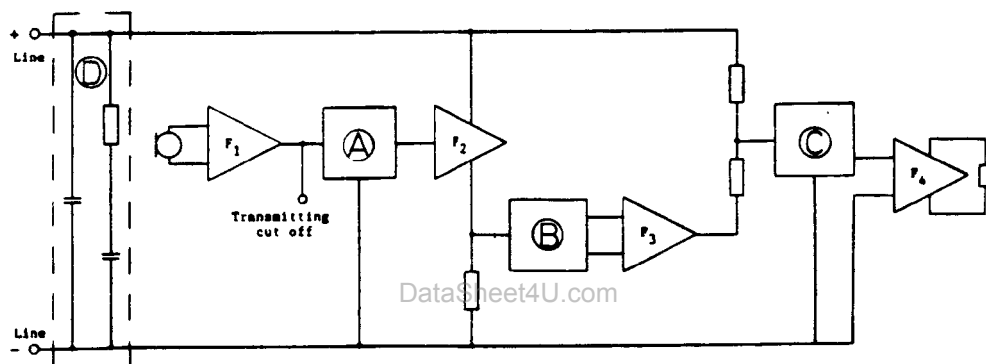
**FUNCTIONAL DESCRIPTION (cont.)**

The side-tone balance can be set by a RC network without influence on other parameters. An inexpensive solution requires only one capacitor while more capacitors can give better performance. The side-tone can be regulated with respect to line length.

A separate amplifier stage ( $F_3$ ) can be used in several different ways, for instance:

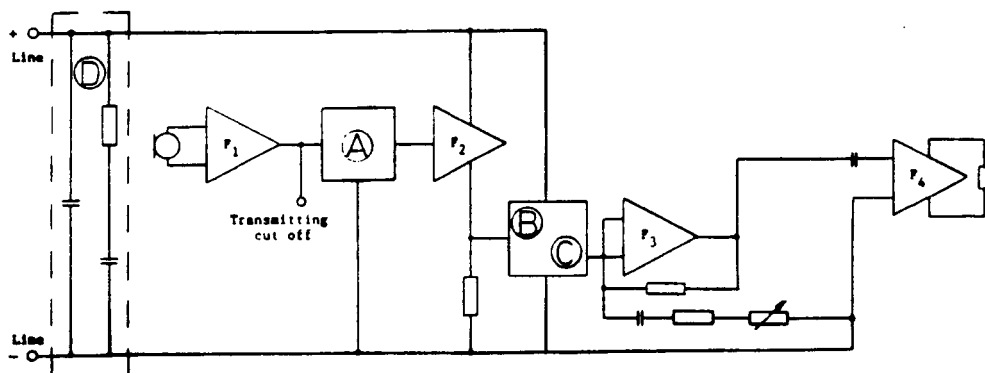
- 1) Separating the side-tone balancing network.
- 2) Line length compensation of side-tone level.
- 3) Give an extra 20 dB gain with volume control for the receiving amplification etc.

The number of possibilities this amplifier gives are very large. In the following part only two examples of its use are given.



A, B, C and D are RC links with the following functions:

- A) To set the gain and frequency response for the transmitter.
- B) To set the side-tone level (regulation with line length is possible).
- C) To set the gain and frequency response for the receiver.
- D) For radio interference suppression and to give the correct return loss behaviour.



In this case an extra 20 dB amplification is added to the receiving part. A potentiometer gives the possibility to adjust the gain to the required level.

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**DESCRIPTION OF EXTERNAL COMPONENTS****R<sub>1</sub>, R<sub>2</sub>:**

These resistors sets the starting point for the gain and side-tone regulation.

Input impedance for pin 6 is about  $5.5 \text{ k}\Omega \pm 20 \%$

Below are some typical values for R<sub>1</sub> and R<sub>2</sub> for some different supplies from telephone stations.

Type	R <sub>1</sub>	R <sub>2</sub>	R <sub>6</sub>
No regulation. Set for long line gain. 200 and 400Ω feedings.	100 kΩ	∞	47 - 75 Ω
No regulation. Set for short line gain. All feedings.	∞	22 kΩ	47 - 100 Ω
Regulation:			
48.5 V, 2 * 200 Ω	∞	∞	47 Ω
48.5 V, 2 * 400 Ω	∞	∞	75 Ω
36.5 V, 2 * 500 Ω	∞	120 kΩ	100 Ω

Previous users of PBL 3726/6 to 3726/15 may note that the two resistors works the opposite way and that only one or none of them is necessary.

**R<sub>3</sub>, C<sub>1</sub>, C<sub>2</sub>:**

C<sub>1</sub> in series with R<sub>3</sub> and those in parallel with C<sub>2</sub> gives the impedance to the line from the set.

C<sub>2</sub> must normally be applied for the radio interference suppression too.

The network should be optimized with regard to the return loss.

The time constant R<sub>3</sub>, C<sub>1</sub> is not allowed to be too small. This generates distortion at low frequencies, because of the gain-regulation.

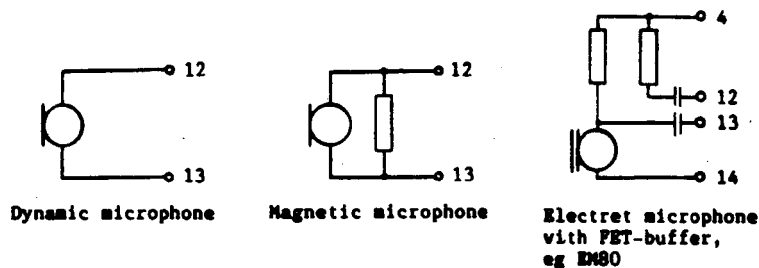
If R<sub>3</sub> is changed this will change the DC characteristic too which is set by the voltage at pin 4. The input current at pin 4 is about 1 mA.

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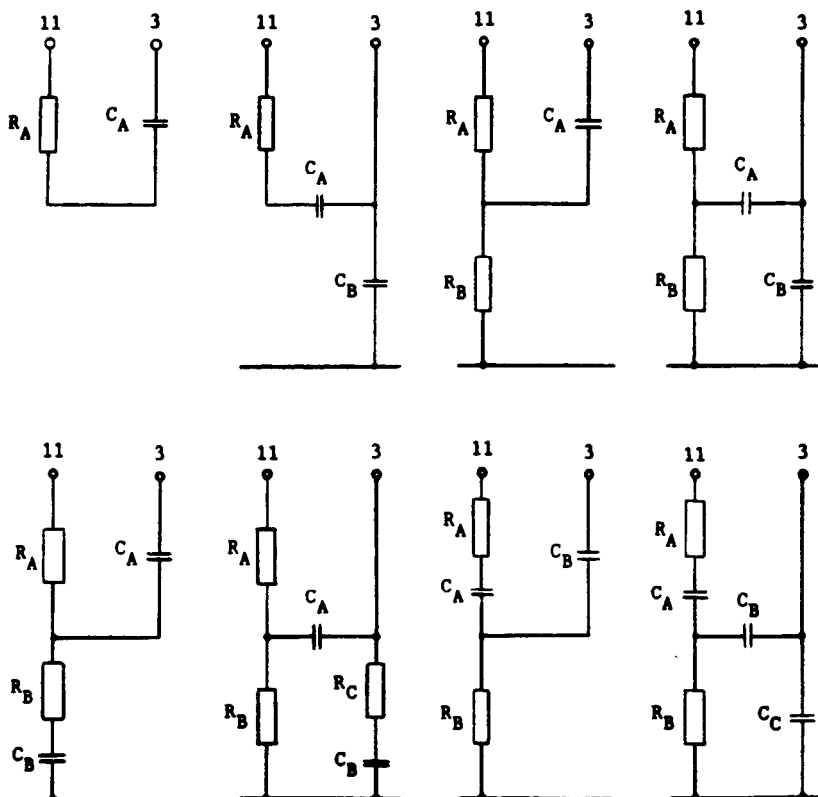
**DESCRIPTION OF EXTERNAL COMPONENTS (cont.)****Mic, R<sub>16</sub>:**

The microphone can be either dynamic, magnetic or electret. See applications below.

The input impedance between pin 12 and 13 is about 1.7 kΩ with typical variation  $\pm 20\%$ .

**R<sub>4</sub>, R<sub>5</sub>, C<sub>3</sub>, C<sub>4</sub>:**

The network gives the amplification and frequency response for the transmitter. R<sub>5</sub> is used when a greater reduction of the gain is wanted. Input impedance at pin 3 is about 17 kΩ with typical variation  $\pm 20\%$ . The sum of the resistors R<sub>4</sub> and R<sub>5</sub> must not be less than 35 kΩ. (This because of DC current to ground.) Below are some simple variations of this network:



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**DESCRIPTION OF EXTERNAL COMPONENTS (cont.)** **$R_6$ :**

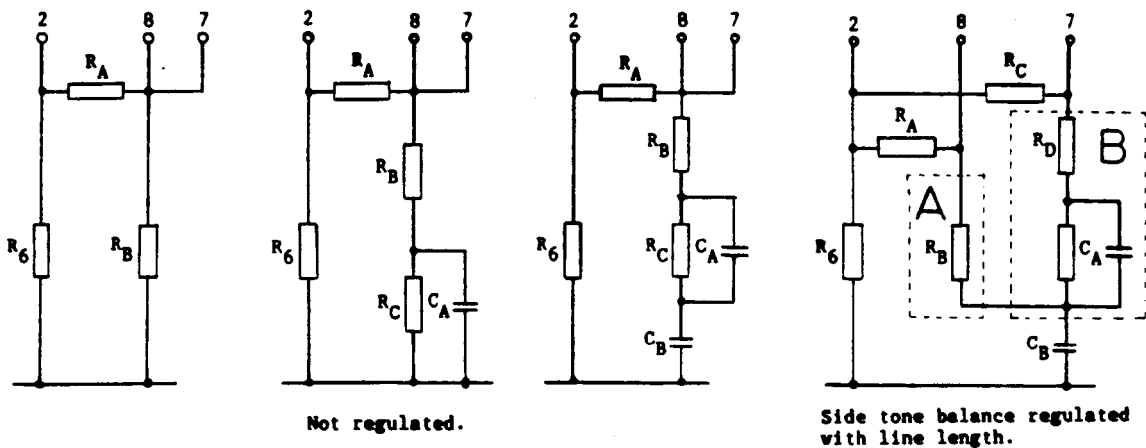
This resistor sets the DC characteristic and takes care of some of the supplied power. The resistor have also function with the protection of the circuit, the transmitter gain, the output amplitude from the transmitter, the gain regulation and the side-tone. Common values are 47  $\Omega$  to 100  $\Omega$ .

 **$R_7, R_8, R_9, R_{10}, R_{11}, C_5$ :**

The network set the side-tone balance. The network in the application is one of many possibilities.  $R_{10}$  and  $R_{11}$  balance together the signals that goes two different ways from the transmitter output stage, one from pin 1 and the other from pin 2. The balance network consists of  $R_8, R_9$  and  $C_5$ .

The examples are not optimized to any specified line, they are only given to show the principle. When designing for lines with high impedance and therefore using a high value for  $R_6$ , there is a risk that, at high currents, the input at amplifier  $F_3$  will saturate and give very high distortion. This is solved by putting a big capacitor in series with  $R_7$ .

The inputs of the amplifier  $F_3$  is high ohmic. Below follows some side-tone network.



Construction of a side-tone network with regulation according to above can be done as follows:

The balance impedance A is optimized at short line where the regulation start. The balance impedance B is optimized at long line where the regulation stops. The circuit generates a continuous change between the two balance impedances.

**RIFA**

## Article list

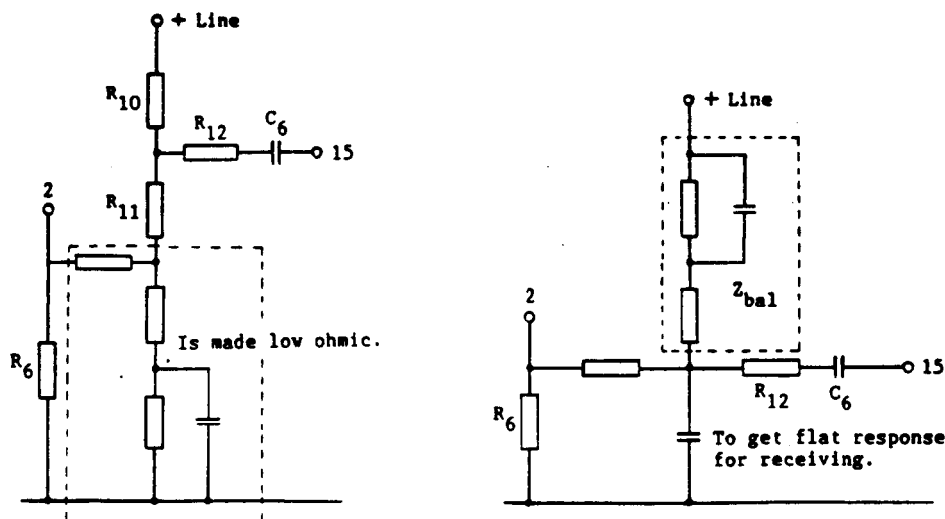
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**DESCRIPTION OF EXTERNAL COMPONENTS (cont.)**

By breaking up between pin 9 and 10,  $F_3$  can be used as an amplifier with amplification higher than one. Here follows two balance networks without  $F_3$ .  $F_3$  can then be used for other things.

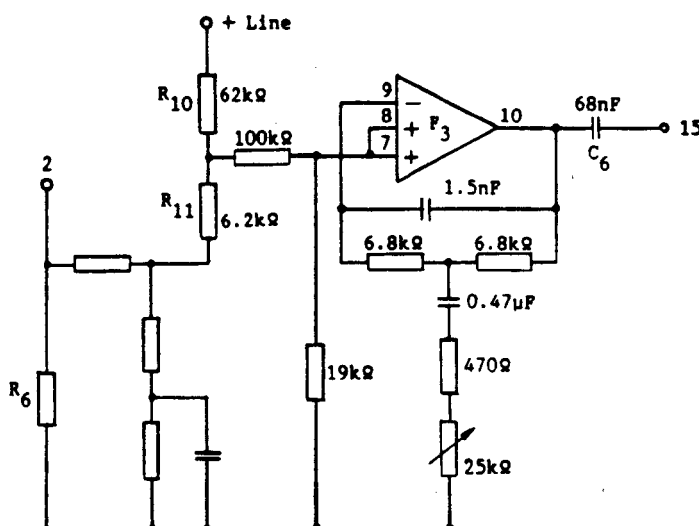
The one to the right is especially suited for lines with low supply impedance.



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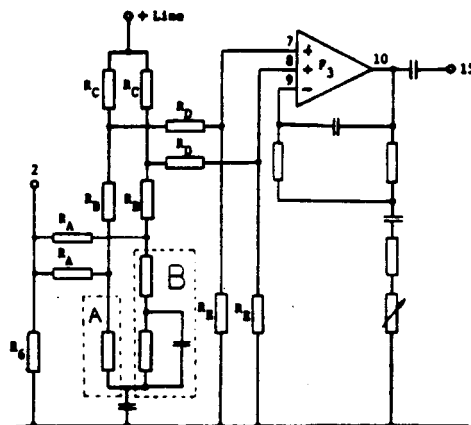
Here is a circuit where  $F_3$  is used as an amplifier with an extra 20 dB gain at receiving and with a volume control.



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**DESCRIPTION OF EXTERNAL COMPONENTS (cont.)**

And at last an example where you get both side-tone regulation with line length and extra amplification with volume control.

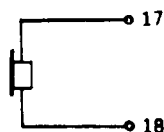


$R_{12}, R_{13}, C_6, (R_{10}, R_{11})$ :

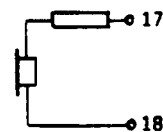
The network gives the gain and frequency response for the receiver.  $R_{13}$  is used when a greater reduction of the gain is wanted. Input impedance at pin 15 is about 35 k $\Omega$  with typical variation  $\pm 20\%$ . For different possibilities for the design of the network, see the network for the transmitter ( $R_4, R_5, C_3$ ).

Rec,  $R_{14}$ :

$R_{14}$  generates the output impedance to the magnetic earphone. If a dynamic earphone is used it should be placed between pin 17 and 18. This will give about the double swing (at the same output current).



Dynamic receiver



Magnetic receiver

$D_1, D_2, D_3, D_4, D_5$ :

Rectifier bridge and overvoltage protection. The zenervoltage at  $D_5$  ought to be as low as possible. Common value is between 12 V and 16 V.

$R_{15}$ :

This resistor is used to set the driving capability of the receiver output amplifier. Common values are 0  $\Omega$  to 50  $\Omega$ . Setting it for low driving capability results in function at lower line current.

**RIFA**

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**DESIGN ORDER**

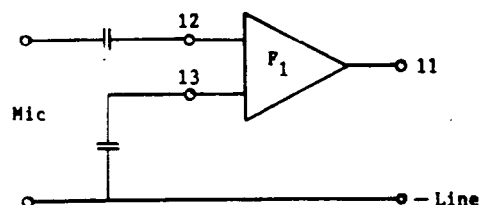
1. The circuit impedance to the line.
2. DC characteristic.
3. Gain regulation.
4. Transmitter gain and frequency response.
5. Receiver gain and frequency response.
6. Side-tone.

To that one usually have to add components to suppress radio interference, especially at the wires to the handset.

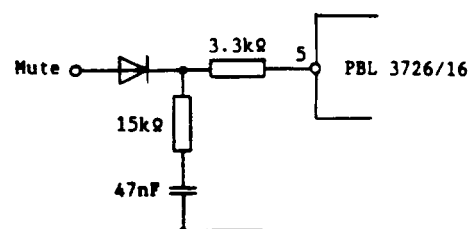
**Others:**

The circuit can be placed either in the telephone or in the handset.

The circuit can be provided with an unbalanced input e.g. as follows:

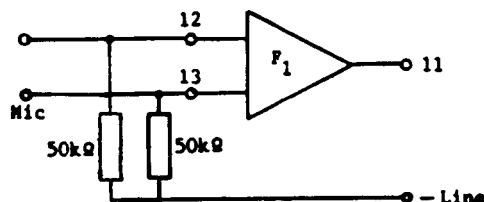


A circuit to reduce disturbing clicks when muting the circuit is shown below. The diode is not needed when using PBD 3535 or PBD 3552.



Cut-off of the transmitter can be done at  $F_1$  without interference of other functions of the circuit.

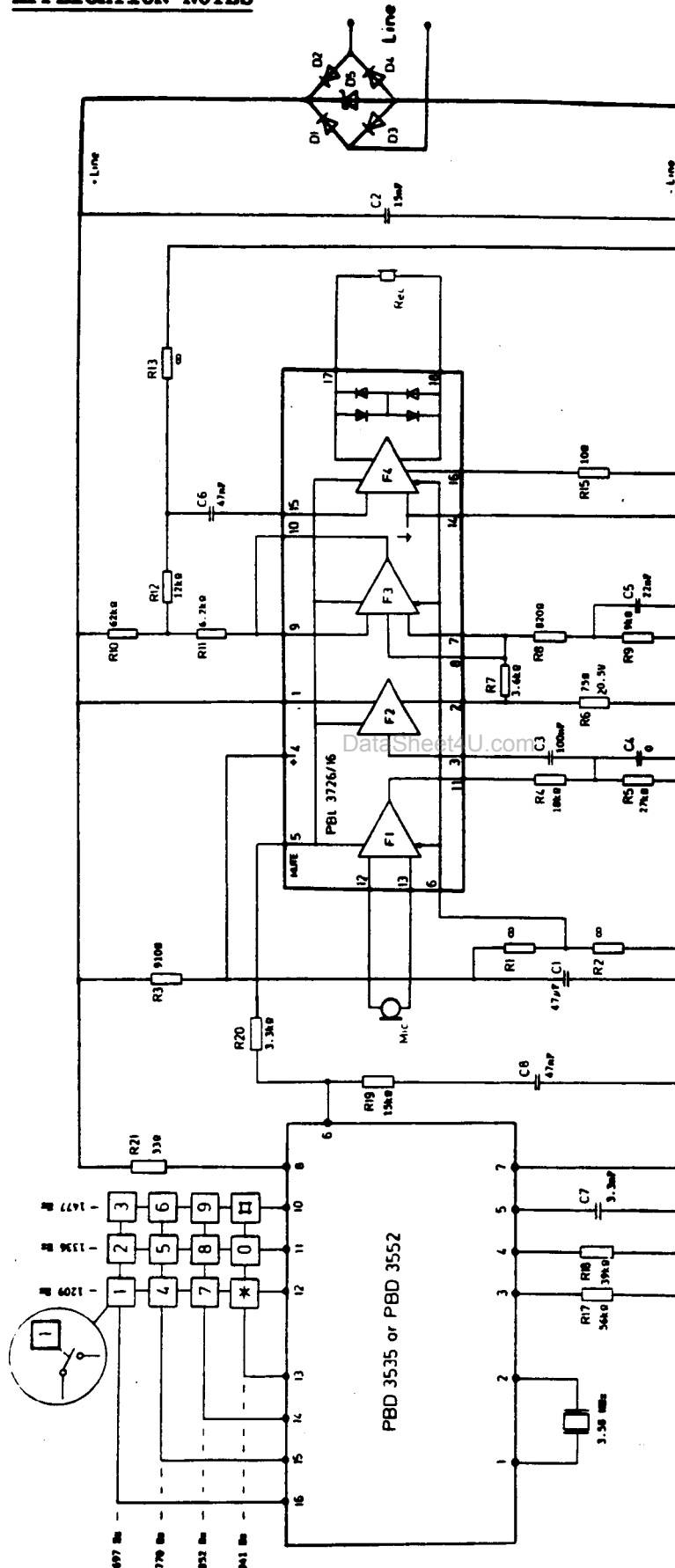
When using the extended low current and low voltage range (5mA, 2V), two resistors have to be connected from the microphone input to ground as below:





Uppgjord - Prepared <b>M/TI2 G Engström</b>	Tekn ansv - Technical responsible <b>M/TI2C</b>	Nr - No <b>120 PBL 3726/16N</b>
Dokansv/Godk - Doc respons/Approved <b>M/T0</b>	Granskad - Checked <b>M/TI2C</b>	Datum - Date <b>1987-10-08</b>
		Rev <b>A</b>
		File <b>PBL372616.120N</b>

**APPLICATION NOTES**



PBL 3726/16 with PBD 3535 or PBD 3552 using dynamic microphone and receiver. Feed: 2 \* 400 Ω 48.5 V. Min current 13mA. DTMP levels: high group -6dB, low group -8dB.

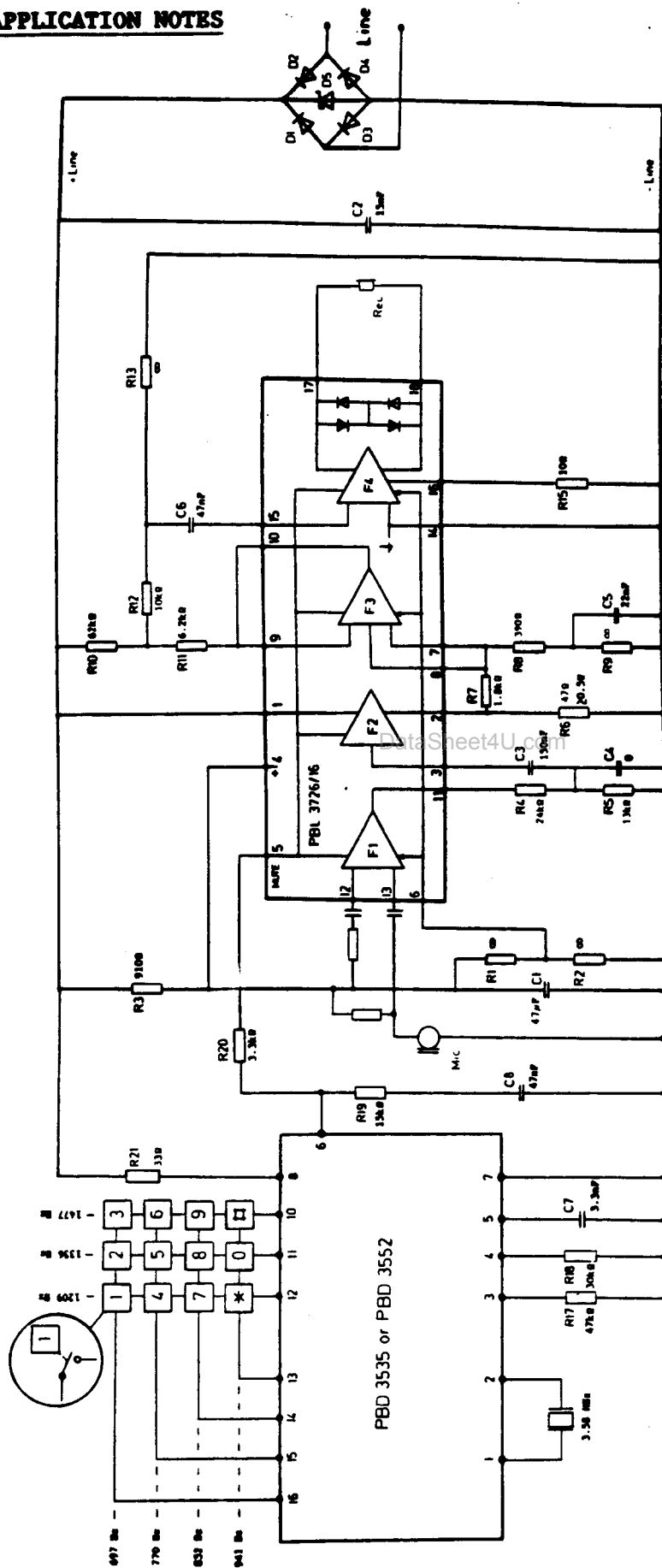
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Uppgjord - Prepared <b>M/TI2 G Engström</b>	Tekn. ansv - Technical responsible <b>M/TI2C</b>	Nr - No <b>120 PBL 3726/16N</b>
Dokansv/Godk - Doc respons/Approved <b>M/T0</b>	Granskad - Checked <b>M/TI2C</b>	Datum - Date <b>1987-10-08</b>
		Rev <b>A</b>
		File <b>PBL372616.120N</b>

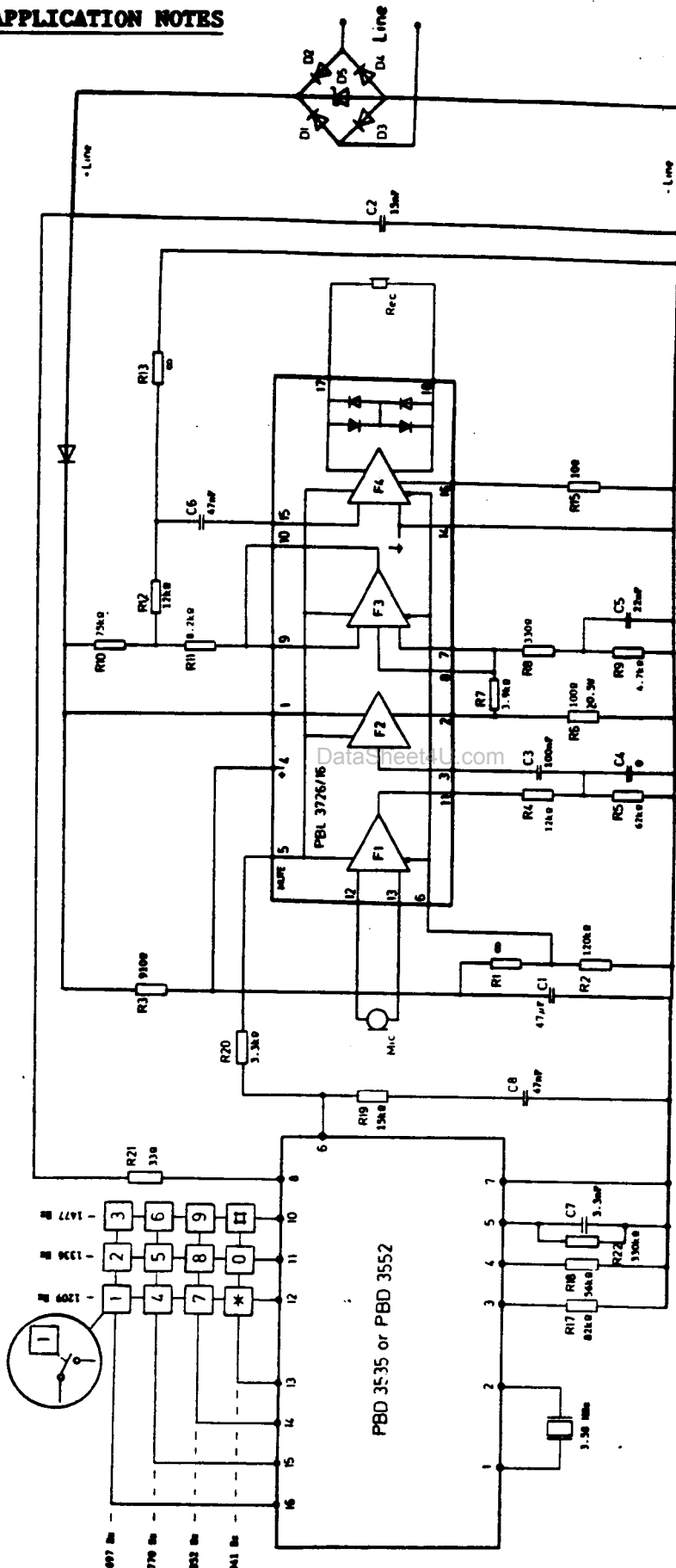
**APPLICATION NOTES**



PBL 3726/16 with PBD 3535 or PBD 3552 using electret microphone and dynamic receiver. Feed: 2 \* 200 Q 48.5 V. Min current 14mA. DTMP levels: high group -4dB, low group -6dB.

Uppgjord - Prepared <b>M/TI2 G Engström</b>	Tekn. ansv. - Technical responsible <b>M/TI2C</b>	Nr - No <b>120 PBL 3726/16N</b>
Dokansv/Godk - Doc respons/Approved <b>M/TO</b>	Granskad - Checked <b>M/TI2C</b>	Datum - Date <b>1987-10-08</b>
		Rev <b>A</b>
		File <b>PBL372616.120N</b>

### APPLICATION NOTES



PBL 3726/16 with PBD 3535 or PBD 3552 using dynamic microphone and dynamic receiver. Feed: 2 \* 500 Ω 36.5 V. Min current 10mA. DTMP levels: high group -9dB, low group -11dB.