

# PBL 3726/18A

## Universal Speech Circuit

### Description

PBL 3726/18A is a standard version of the PBL 3726 family of the mask-programmable, monolithic integrated speech circuits for use in electronic telephones.

It is designed for use with a low impedance microphone. Transmitting and receiving gain is regulated with line length. Different regulation for various current feeds can be set by external resistors. Typical current feeds as 48 V, 2 x 200 ohm, 48 V 2 x 400 ohm and 48 V 2 x 800 ohm can be handled. Application dependent parameters such as line balance, side tone level, amplification and frequency response are set by external components. Parameters are set independently which means easy adoption for various market needs.

### Key Features

- Minimum number of inexpensive external components, 7 capacitors and 11 resistors.
- Mute function for operation with DTMF-generator.
- Transmit and receive gain regulation for automatic loop loss compensation.
- Extended current and voltage range 5 - 130 mA, down to 2 V.
- Differential microphone input for good balance to ground.
- Balanced receiver output stage.
- Short start-up time.
- Stabilized DC-supply for low current CMOS diallers and/or electret microphones.
- DTMF-input controlled by mute.

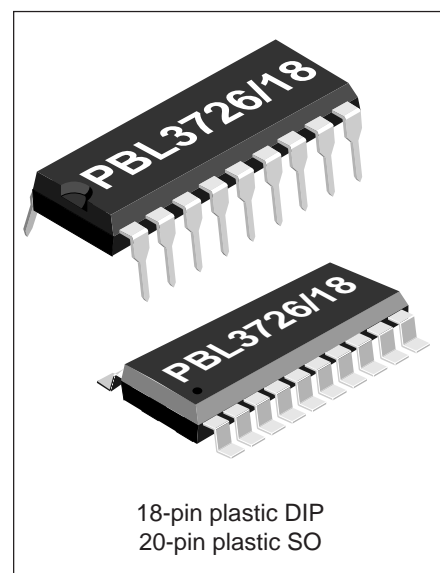
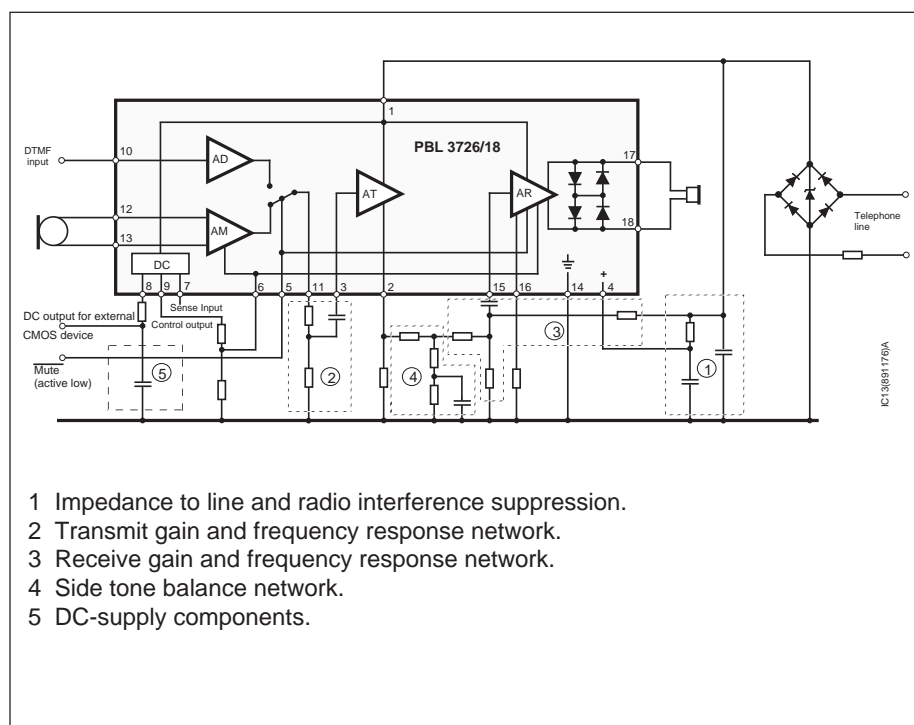


Figure 1. Functional diagram. DIP package.

## Maximum Ratings

| Parameter                           | Symbol    | Min | Max  | Unit |
|-------------------------------------|-----------|-----|------|------|
| Line voltage, $t_p = 2$ s           | $V_L$     | 0   | 18   | V    |
| Line current, continuous DIP        | $I_L$     | 0   | 130  | mA   |
| Line current, continuous SO package | $I_L$     | 0   | 100  | mA   |
| Operating temperature range         | $T_{Amb}$ | -40 | +70  | °C   |
| Storage temperature range           | $T_{Stg}$ | -55 | +125 | °C   |

No input should be set on higher level than pin 4 (+C).

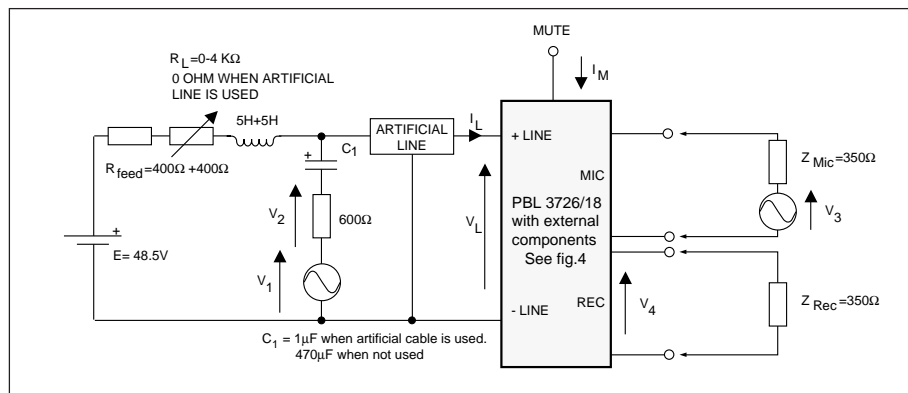


Figure 2. Test set up without rectifier bridge.

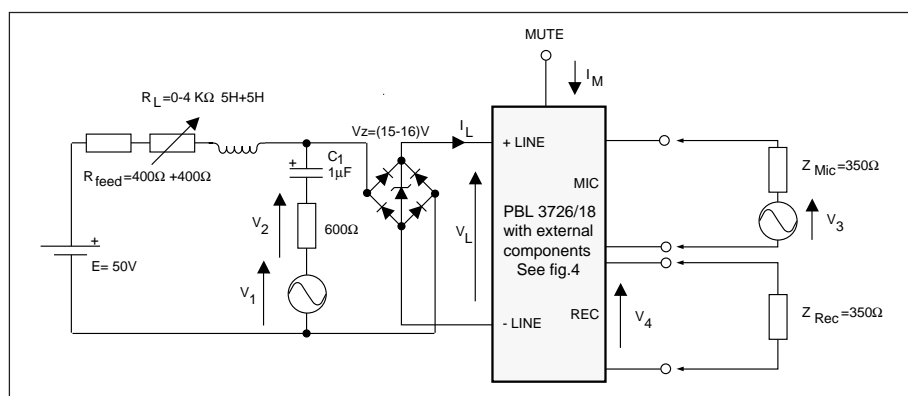


Figure 3. Test set up with rectifier bridge.

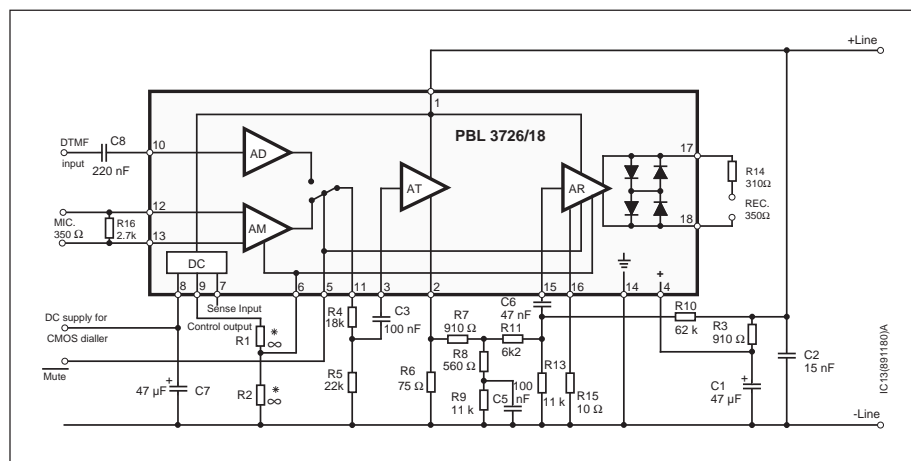


Figure 4. Circuit with external components for test set up.  
\* Not used in test set up.  
DIP package pinning.

## Electrical Characteristics

At  $T_{Amb} = +25^{\circ}\text{C}$ . No cable and no line rectifier unless otherwise specified.

| Parameter  | Ref. fig. | Conditions   | Min   | Typ                  | Max   | Unit                |
|--|-----------|--|-------|----------------------|-------|---------------------|
| Line voltage, $V_L$                                  | 2         | $I_L = 15\text{ mA}$   | 3.3   | 3.7                  | 4.1   | V                   |
|  | 2         | $I_L = 100\text{ mA}$  | 11    | 13                   | 15    | V                   |
| Transmitting gain, note 1                            |           | $20 \cdot \log(V_2/V_3)$ ; 1 kHz   |       |                      |       |                     |
|  | 2         | $R_L = 0$  | 41    | 43                   | 45    | dB                  |
|  | 2         | $R_L = 400\ \Omega$  | 43.5  | 45.5                 | 47.5  | dB                  |
|  | 2         | $R_L = 900\ \Omega - 2.2\text{ k}\Omega$   | 46    | 48                   | 50    | dB                  |
| Transmitting range of regulation                     | 2         | 1 kHz, $R_L = 0$ to $900\ \Omega$  | 3     | 5                    | 7     | dB                  |
| Transmitting frequency response                      | 2         | 200 Hz to 3.4 kHz  | -1    |                      | 1     | dB                  |
| Receiving gain, note 1                               |           | $20 \cdot \log(V_4/V_1)$ ; 1 kHz   |       |                      |       |                     |
|  | 2         | $R_L = 0\ \Omega$  | -18.5 | -16.5                | -14.5 | dB                  |
|  | 2         | $R_L = 400\ \Omega$  | -16   | -14                  | -12   | dB                  |
|  | 2         | $R_L = 900\ \Omega - 2.2\text{ k}\Omega$   | -13.5 | -11.5                | -9.5  | dB                  |
| Receiving range of regulation                        | 2         | 1 kHz, $R_L = 0$ to $900\ \Omega$  | 3     | 5                    | 7     | dB                  |
| Receiving frequency response                         | 2         | 200 Hz to 3.4 kHz  | -1    |                      | 1     | dB                  |
| Microphone input impedance<br>pin 12 (14), 13 (15)   | 2         | 1 kHz  |       | 1.7(//2.7)<br>note 3 |       | k $\Omega$          |
| Transmitter input impedance<br>pin 3                 | 2         | 1 kHz  | 13.5  | 17                   | 20.5  | k $\Omega$          |
| Transmitter dynamic output                           | 2         | 200 Hz - 3.4 kHz<br>$\leq 2\%$ distortion, $I_L = 20 - 100\text{ mA}$  |       | 1.5                  |       | $V_p$               |
| Transmitter max output                               | 2         | 200 Hz - 3.4 kHz<br>$I_L = 0 - 100\text{ mA}$ , $V_3 = 0 - 1\text{ V}$   |       | 3                    |       | $V_p$               |
| Receiver output impedance                            | 2         | 1 kHz,   |       | 3(+310)note 3        |       | $\Omega$            |
| Receiver dynamic output<br>note 2                    | 2         | 200 Hz - 3.4 kHz<br>$\leq 2\%$ distortion, $I_L = 20 - 100\text{ mA}$  |       | 0.5                  |       | $V_p$               |
| Receiver max output                                  | 3         | Measured with line rectifier<br>200 Hz - 3.4 kHz, $I_L = 0 - 100\text{ mA}$ , $V_1 = 0 - 50\text{ V}$                          |       | 0.9                  |       | $V_p$               |
| Transmitter output noise                             | 2         | Psoph-weighting, Rel 1 $V_{rms}$ , $R_L = 0$   |       | -75                  |       | dB <sub>Psoph</sub> |
| Receiver output noise                                | 2         | A-weighting, Rel 1 $V_{rms}$ , with cable<br>0 - 5 km, $\varnothing = 0.5\text{ mm}$ , 0 - 3 km, $\varnothing = 0.4\text{ mm}$ |       | -85                  |       | dB <sub>A</sub>     |
| Mute input voltage<br>at mute (active low)           | 2         |  |       |                      | 0.3   | V                   |
| DC-supply voltage                                    | 2         | $I_L = 10 - 100\text{ mA}$   |       |                      |       |                     |
|  |           | $I_{DC} = 0\text{ mA}$   | 2.1   | 2.35                 | 2.6   | V                   |
|  |           | $I_{DC} = 2\text{ mA}$   | 1.95  | 2.2                  | 2.45  | V                   |
| DC-supply current, pin 8.                            | 2         |  | 2     |                      |       | mA                  |
| DC-output pin 8 input<br>leakage current (no supply) | 4         | $V_{DC} = 2.35\text{ V}$   |       | 0.1                  |       | $\mu\text{A}$       |
| DTMF transmitting gain                               | 2         | $V_M = 0.3\text{ V}$ , 1 kHz   | 24.5  | 26.5                 | 28.5  | dB                  |
| DTMF input impedance                                 | 2         | 1 kHz  | 20    | 25                   | 30    | k $\Omega$          |

### Notes

- Adjustable to both higher and lower values with external components.
- The dynamic output can be doubled, see applications information.
- External resistor in the test set up.

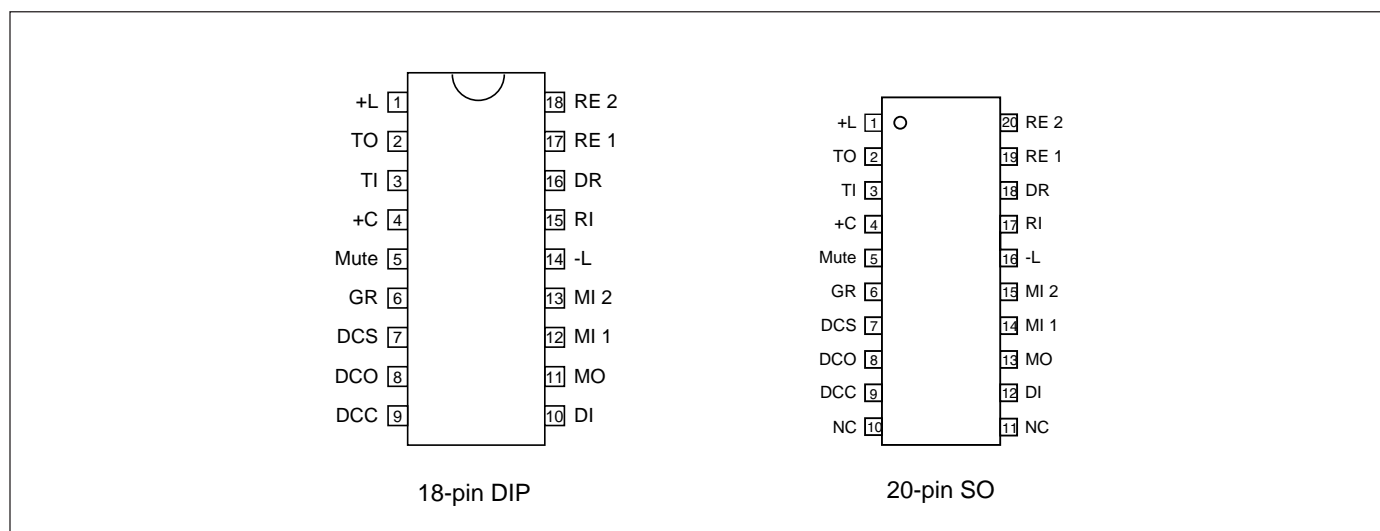


Figure 5. Pin configuration.

## Pin Descriptions

Refer to figure 5.

| DIP | SO | Name | Function  |
|-----|----|------|---|
| 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 through a resistor of 47 to 100 ohm to -L, which 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   | 3  | TI   | Input of transmit amplifier. Input impedance 17 kohm $\pm$ 20 %.  |
| 4   | 4  | +C   | This pin is the positive power supply terminal for most of the circuitry inside the PBL 3726/18A (about 1 mA current consumption). The +C pin shall be connected to a decoupling capacitor of 47 $\mu$ F to 150 $\mu$ F.                                |
| 5   | 5  | Mute | When low, speech circuit is muted and the DTMF input is enabled. Maximum voltage (at mute) is 0.3 V, current sink requirement of external driver is 50 $\mu$ A.   |
| 6   | 6  | GR   | This pin is control input for the gain regulation circuitry.  |
| 7   | 7  | DCS  | This pin is the sense input to the DC-supply.   |
| 8   | 8  | DCO  | This pin is the output from the DC-supply.  |
| 9   | 9  | DCC  | This pin is the control output from the DC-supply.  |
| 10  | 12 | DI   | This pin is the input for the DTMF-signal. Input impedance is 25 kohm $\pm$ 20 %.   |
| 11  | 13 | MO   | Output of the microphone amplifier or DTMF-amplifier.   |
| 12  | 14 | MI 1 | Inputs to the microphone amplifier. Input impedance 1.7 kohm $\pm$ 20 %.  |
| 13  | 15 | MI 2 |   |
| 14  | 16 | -L   | The negative power terminal, connected to the line through a polarity guard diode bridge.   |
| 15  | 17 | RI   | Input of receiver amplifier. Input impedance is approximately 38 kohm $\pm$ 20 %.   |
| 16  | 18 | DR   | This pin is the control input for the receiver amplifier driving capability.  |
| 17  | 19 | RE 1 | Receiver amplifier outputs. Output impedance is approximately 3 ohm.  |
| 18  | 20 | RE 2 |   |
|     | 10 | NC   | NC  |
|     | 11 | NC   | NC  |

## Functional Description

### General

The gain of the transmitting and receiving amplifiers are continuously and equally changed with the line length. The starting point for the gain regulation is externally set. The gain regulation can be cut-off externally, see table under gain regulation below.

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 voltage, DC-supply for external use and for the transmitting and receiving gain regulation. The DC line 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 7 external capacitors of which only two are electrolytic/tantalum filter capacitor. One of the other capacitors is needed as radio interference suppression capacitor over the line, one capacitor in the side-tone balancing network and one capacitor for low frequency cut-off in each of the transmitting and receiving amplifiers. The frequency response is, except for that, flat for both amplifiers.

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

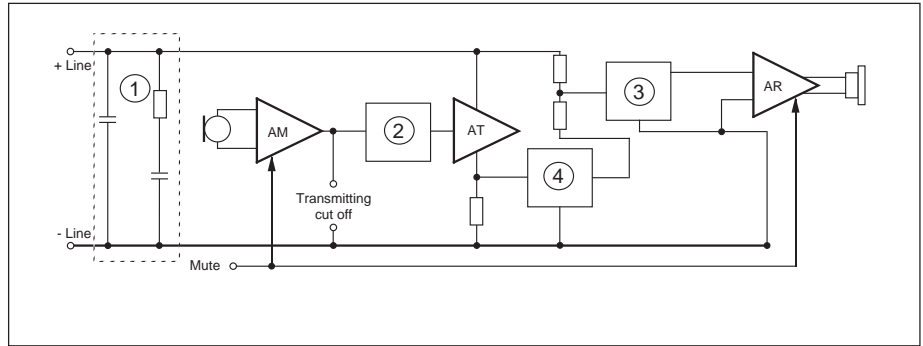


Figure 6. Block interconnections.

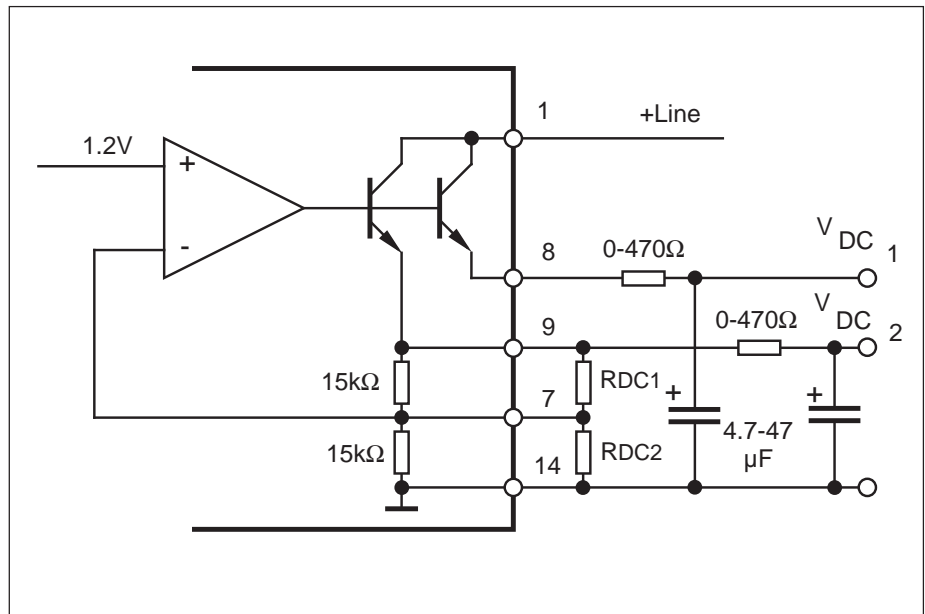


Figure 7. DC regulator for external CMOS devices. 18-pin DIP pin numbers.

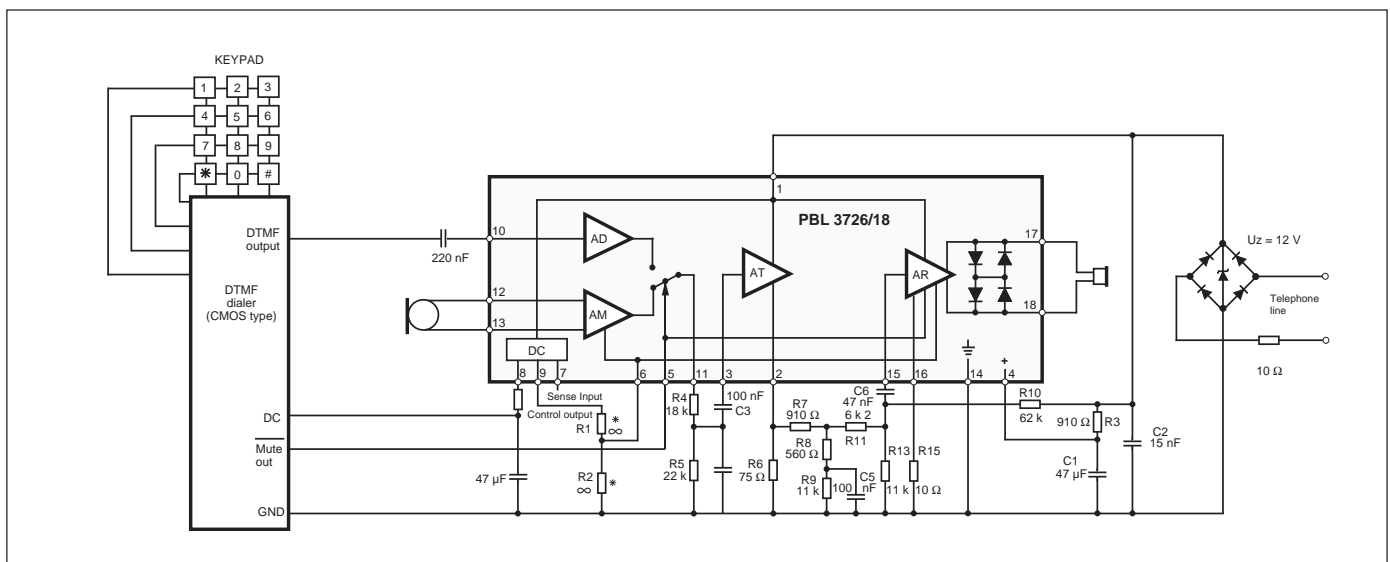


Figure 8. Typical tone dialling telephone. Pinning DIP package.

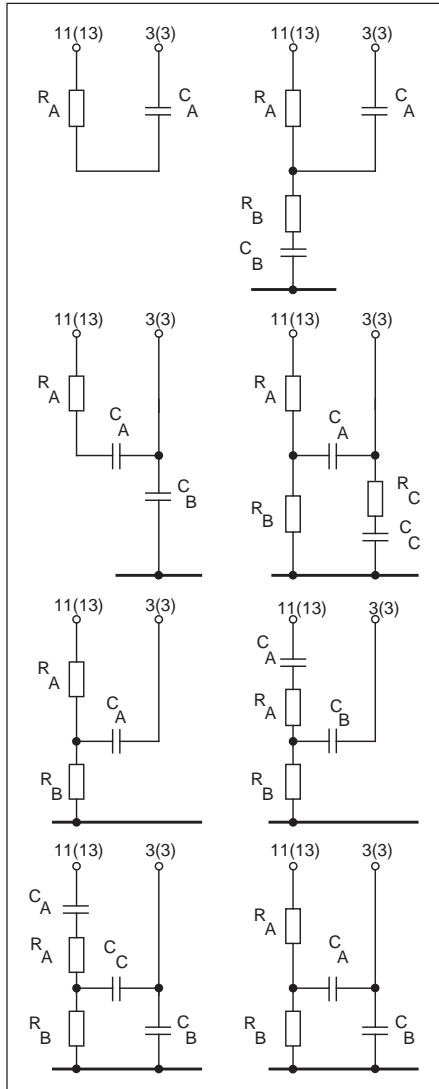


Figure 9. Examples of network "2".

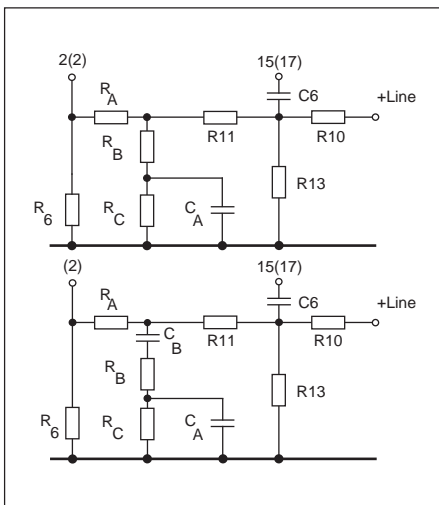


Figure 10. Examples of network "4".

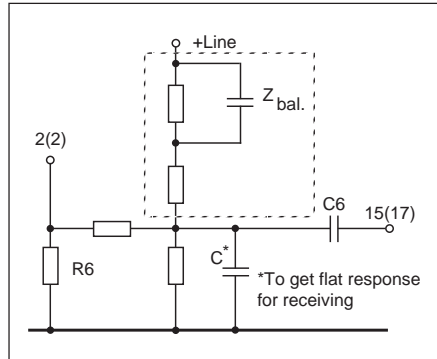


Figure 11. Sidetone network especially suited for applications with a high line current, when R6 has a low value or when a high receiver gain is needed.

A mute input is included in the circuit.

It gives:

1. Cut-off the microphone amplifier.
2. Reduced gain in the receiving amplifier.
3. Connection of the DTMF input.

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.

An inexpensive sidetone balancing network requires only one capacitor while more capacitors can give better performance (figure 10).

In figure 6: 1, 2, 3 and 4 are RC-links with the following functions:

1. For radio interference suppression and to give the correct return loss behaviour.
2. To set the gain and frequency response for transmitting.
3. To set the gain and frequency response for receiving.
4. To set the side-tone level.

A double, stabilized DC series regulator, with a pre-set output voltage of 2.35 Volts, is provided to facilitate interfacing to external CMOS dialler ICs. The voltage is adjustable with two resistors ( $R_{DC1}$  and  $R_{DC2}$ ) as indicated in figure 7. The output requires some filtering to avoid distortion on the telephone line. Note that a high current consumption of the external device will

alter the DC characteristics of the speech circuit.

To get a good CMRR the microphone input is balanced.

To get the extended low current and voltage range two resistors have to be connected from microphone input to ground (figure 14).

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.

## Applications Information

Refer to figure 8.

### Gain regulation (R1, R2)

These resistors set the starting point for the transmit and receive gain regulation.

Input impedance pin 6 is about 5.5 kohm  $\pm$  20 %.

Below are some typical values for R1 and R2 ( $V_{pin8} = 2.35$ ), for some different supplies from telephone stations.

| Battery feed                 | R1            | R2             | R6              |
|------------------------------|---------------|----------------|-----------------|
| No regulation.               |               |                |                 |
| Set for short line gain.     |               |                |                 |
| All feedings.                | $\infty$      | 22 k $\Omega$  | 47-100 $\Omega$ |
| No regulation.               |               |                |                 |
| Set for long line gain.      | 18 k $\Omega$ | $\infty$       | 47 $\Omega$     |
| Set for long line gain.      | 22 k $\Omega$ | $\infty$       | 75-100 $\Omega$ |
| Regulation:                  |               |                |                 |
| 48 V, 2 $\cdot$ 200 $\Omega$ | $\infty$      | $\infty$       | 47 $\Omega$     |
| 48 V, 2 $\cdot$ 400 $\Omega$ | $\infty$      | $\infty$       | 75 $\Omega$     |
| 36 V, 2 $\cdot$ 500 $\Omega$ | $\infty$      | 180 k $\Omega$ | 100 $\Omega$    |
| 48 V, 2 $\cdot$ 800 $\Omega$ | $\infty$      | 180 k $\Omega$ | 100 $\Omega$    |

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.

### Impedance to line (R3, C1, C2)

C1 in series with R3 and those in parallel with C2 give the impedance to the line from the set.

C2 must be there for the radio interference too.

The network is optimized with regard to the return loss.

The time constant R3, C1 cannot be allowed to be too small. If the time constant is too small, distortion at low frequencies may be generated.

If R3 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.

### Microphone selection (M1, R16)

The microphone can be either dynamic, magnetic or electret. See figures 13, 15 and 16.

The input impedance between pin 12 (14) and 13 (15) is about 1.7 kohm with typical variation  $\pm 20\%$ .

### Transmitting gain and frequency response (R4, R5, C3, C4)

The network gives the amplification and frequency response for the transmitter. R5 is used when a greater reduction of the gain is wanted. Input impedance at pin 3 is about 17 kohm with typical variation  $\pm 20\%$ . The sum of the resistors R4 and R5 must not be less than 35 kohm because of DC-current to ground. Figure 9 shows some simple variations of this network.

### DC-characteristics (R6)

Sets the DC-characteristic and take care of some of the supplied power. The resistor have also function with the protection of the circuit, the transmitter, the gain regulation and the side tone. Common values are 47 ohm to 100 ohm.

### Side tone level, receiving gain and frequency response. (R7, R8, R9, R10, R11, C5)

The network sets the side tone balance. The network in the application is one of many possibilities. R10 and R11 balance together the signals that go two different ways from the transmitter output stage one from pin 1 and the other from pin 2. The balance network consists of R8, R9 and C5.

The example is not optimized to any specified line, it is only given to show the principle.

Figures 10 and 11 are examples of balance networks. Figure 11 is especially suited for lines with high current supply.

### R13, C6, (R10, R11)

The networks gives the gain and frequency response for the receiver.

Input impedance at pin 15 (17) is about 38 kohm with a typical variation of  $\pm 20\%$ . For different possibilities for the design of the network, see the network for the transmitter (R4, R5, C3).

### REC, R14

R14 generates the output impedance to the magnetic earphone (figure 12). If a dynamic earphone is used it should be

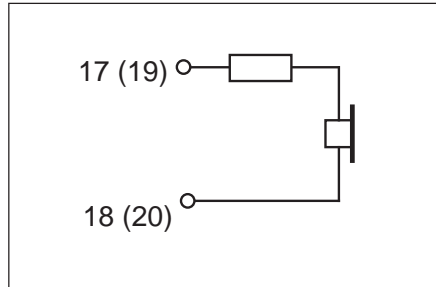


Figure 12. Magnetic receiver connection.

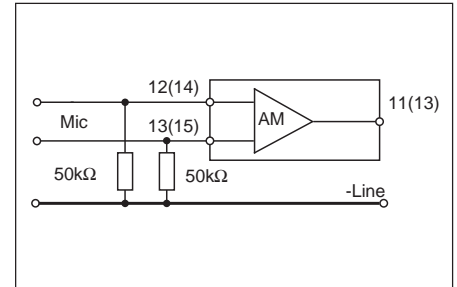


Figure 14. Additional components for extended low current/voltage operation.

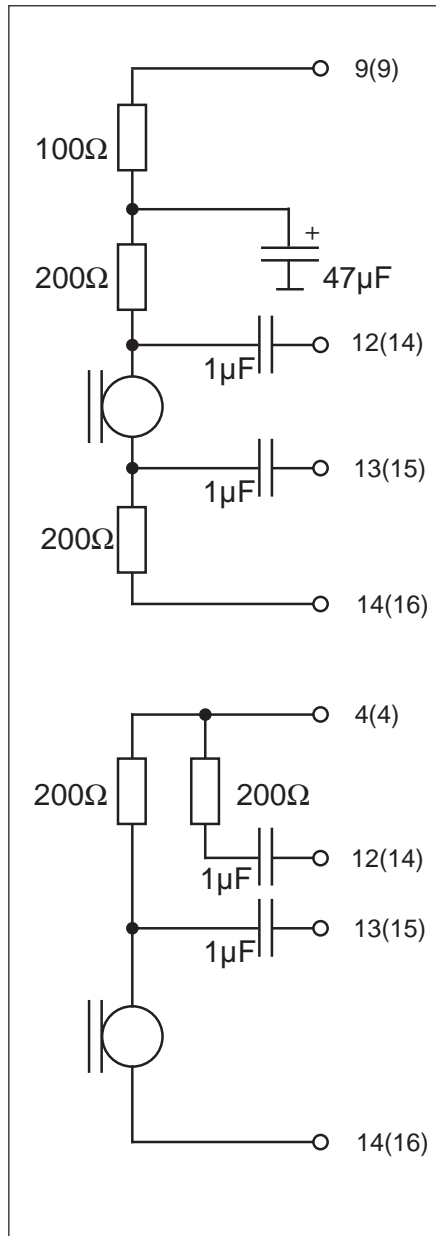


Figure 13. Electret microphone with FET-buffer, e.g. EM80.

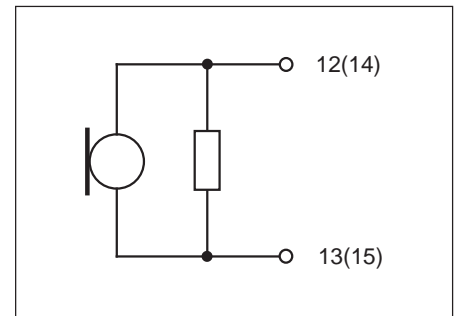


Figure 15. Connection of a magnetic microphone.

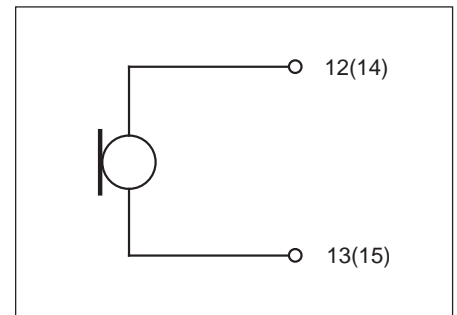


Figure 16. Connection of a dynamic microphone.

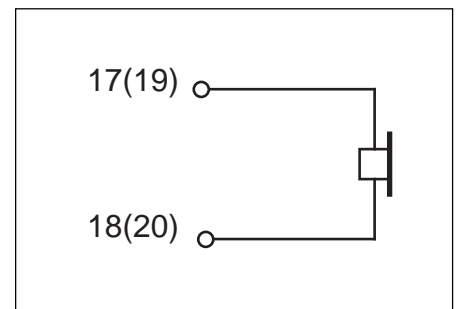


Figure 17. Dynamic receiver connection.

placed between pin 17 (19) and 18 (20). See figure 17.

#### R15

This resistor is used to set the driving capability of the receiver output amplifier. Common values are 0 ohm to 50 ohm. Setting it for low driving capability results in function at lower line current. Breaking up pin 16 (18) will give lower power consumption and total mute of the receiver when muting the circuit.

#### D1, D2, D3, D4, D5

Rectifier bridge and overvoltage protector. The zener voltage at D5 should be as low as possible. Common values are between 12 V - 16 V.

$R_{DC1}$ ,  $R_{DC2}$

Refer to figure 7.

The preset output voltage of 2.35 V can easily, if needed, be changed to another

value by applying one or two resistor (RDC1, RDC2) in parallel with the internal resistors (each  $15\text{ k}\Omega \pm 20\%$ ). It is possible to get a rather high voltage and current from the DC-supply as long as the high current and voltage is available from the line. The DC voltage has to be filtered by a capacitor and this can, at high DC-voltage and low line current, interfere with the signal on the line and cause distortion. The interference can be minimized, with a resistor in series with the filter capacitor. The DC voltage will, of course, be more dependent of the DC-supply current. The DC-output pin has a very low input leak current, to allow stand-by feeding of the dialler. It is also possible to use pin 9 to feed microphones etc. that do not need stand-by feeding, without interfering with the stand-by feeding on pin 8. Note that a high current consumption by the external device will alter the DC characteristics of the speech circuit.

#### Design procedure:

1. 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.
7. Components to suppress radio interference, specially the wires up to the handset.

#### Others:

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

Cut-off of the transmitter can be done at F1 without interference of other functions of the circuit.

When using the extended low current and low voltage range (5 mA, 2 V), two resistors have to be connected from the microphone inputs to ground as shown in figure 14.

## Ordering Information

| Package     | Temp. Range  | Part No.         |
|-------------|--------------|------------------|
| Plastic DIP | -40 to +70°C | PBL 3726/18AN    |
| Plastic SO  | -40 to +70°C | PBL 3726/18ASO   |
| Plastic SO  | -40 to +70°C | PBL 3726/18ASO-T |

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**ERICSSON** 

**Ericsson Components AB**

S-164 81 Kista-Stockholm, Sweden

Telephone: (08) 757 50 00