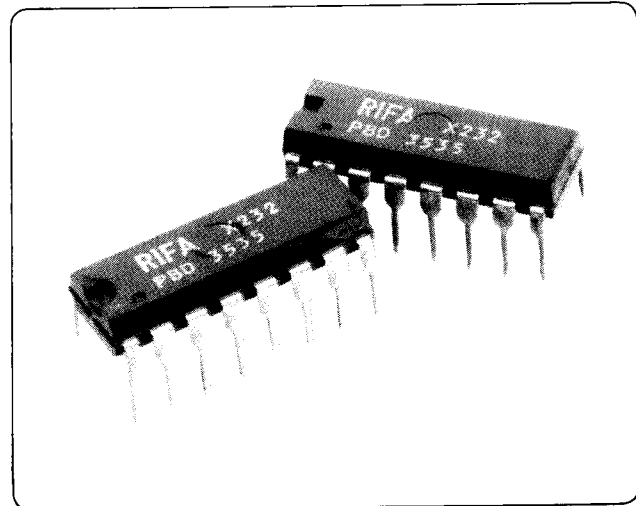


DTMF Generator

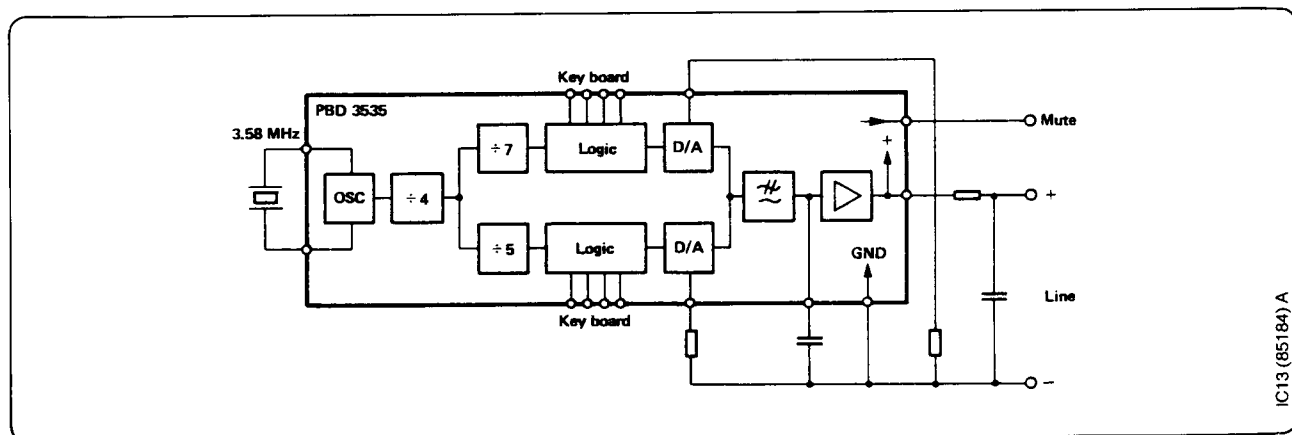
PBD 3535 is a monolithic integrated DTMF generator intended for use in a telephone set in parallel with an electronic speech circuit. The DC characteristic to the line is set by the speech circuit. PBD 3535 gives a mute signal when sending. The circuit fulfils the CEPT specification. Optional signal levels can be set by resistors. The circuit operates with a single contact matrix keyboard. Interfacing with a computer is also possible.

Key Features

- Operates with a standard crystal at 3.58 MHz
- Wide operating line voltage and current range
- Levels from the high and low frequency group can be adjusted separately.
- No individual level adjustment is necessary for every circuit
- The signal levels are stabilized against variations in temperature and line voltage
- Short start-up time
- All tones can be generated separately for testing
- The number of external components is minimized
- Easy PC board layout; all keyboard connections on one side of the circuit
- Internal protection of all inputs
- I²L process ensures good parameter tolerances



Functional Diagram



IC13 (85184) A

Maximum Ratings

Maximum ratings over operating free-air temperature range (unless otherwise stated).

Voltages and Currents

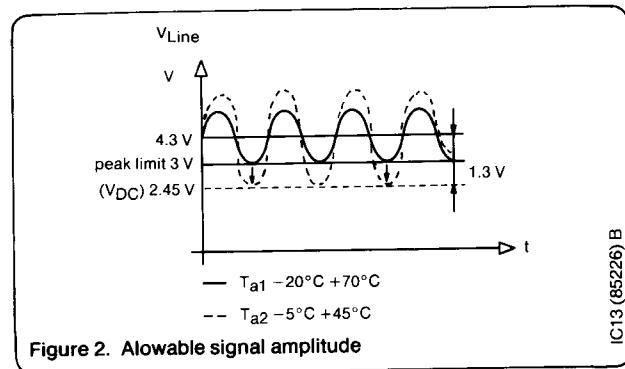
| | | | |
|-----------------------------|--|------------|--------------|
| Max continuous line coltage | | U_{Line} | 13 V |
| Peak line voltage | Pulse time = 2 s Pulse time = 20 ms | U_{Line} | 20 V 22 V |

Temperature Range

| | | | |
|-------------------------------|--|-------|-------------------|
| Junction temperature | | T_j | +150 °C |
| Operation ambient temperature | | T_a | -20 °C to +70 °C |
| Storage temperature | | T_S | -55 °C to +150 °C |

Recommended Operating Conditions

| Symbol | Parameter | Min | Typ | Max | Unit |
|------------|---------------------|-----|-----|-----|------|
| U_{Line} | Line voltage | 4.3 | | 9 | V |
| T_a | Ambient temperature | -20 | | +70 | °C |



Electrical Characteristics

Electrical characteristics over recommended operating conditions. Test Circuit see fig. 3.

| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|-----------------|-----------------------------|---|------|-------|-----|------|
| V_{Line} | Line voltage | Tone generation DC level at 1.3 V _p AC signal (see fig. 2) | 4.3 | | 9 | V |
| V_{DC} | DC voltage below AC voltage | At tone generation | 3.0 | | | V |
| | | At tone generation -5 °C +45 °C (see fig. 2) | 2.45 | | | V |
| V_{Line} | Line voltage | Stand-by DC level at 2.0 V _p AC signal | 4.3 | | 9 | V |
| I_{Line} | Line current | Stand-by: no key pressed $V_{Line} = 4.3$ V | | | 250 | µA |
| I_{Line} | Line current | Operating current $V_{Line} = 4.3$ V | | | 10 | mA |
| I_M | Mute current | One or more keys pressed | 125 | | | µA |
| R_K | Key resistance | Key circuit closed | | | 1 | kohm |
| | | Keys open (16 contacts) | 1 | | | Mohm |
| T_f | Low | $f_{osc} = 3.5795$ MHz | | | | |
| | | $f_1 = 697$ Hz | -1 | +0.32 | +1 | % |
| | | $f_2 = 770$ Hz | -1 | +0.02 | +1 | % |
| | | $f_3 = 852$ Hz | -1 | +0.03 | +1 | % |
| | High | $f_4 = 941$ Hz | -1 | -0.11 | +1 | % |
| | | $f_5 = 1209$ Hz | -1 | -0.03 | +1 | % |
| | | $f_6 = 1336$ Hz | -1 | -0.03 | +1 | % |
| | | $f_7 = 1477$ Hz | -1 | -0.68 | +1 | % |
| $f_8 = 1633$ Hz | -1 | -0.36 | +1 | % | | |
| V_{High} | Signal Level high | $R_H = 47.5$ kohm | -11 | -9 | -7 | dBm |
| V_{Low} | Signal level low | $R_L = 69.8$ kohm | -13 | -11 | -9 | dBm |

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---------------------------------------|--|--|-----|-----|-----|------|
| V _{High} | | R _H = 33.2 kohm | -8 | -6 | -4 | dBm |
| V _{Low} | | R _L = 48.7 kohm | -10 | -8 | -6 | dBm |
| V _{High} | | R _H = 26.1 kohm | -6 | -4 | -2 | dBm |
| V _{Low} | | R _L = 39.2 kohm | -8 | -6 | -4 | dBm |
| V _{High} V _{Low} | Ratio signal level high freq/low freq | | 1 | 2 | 3 | dB |
| Z _T | Impedance to line | At tone generation | 6 | | | kohm |
| Z _S | | At stand-by | 50 | | | kohm |
| D | Total harmonic distortion | Normal operation | | | -31 | dBm |
| | | Stand-by | | | -80 | dBm |
| H | Harmonics | 300-3400 Hz | | | -33 | dBm |
| | | >50 kHz | | | -80 | dBm |
| t _s | Start-up time | Output level within 1 dB from final level | | 3 | 5 | ms |

* Single tone distortion is less than $(-33 - 40 \times \log \frac{f}{3400})$ dBm

Functional Description

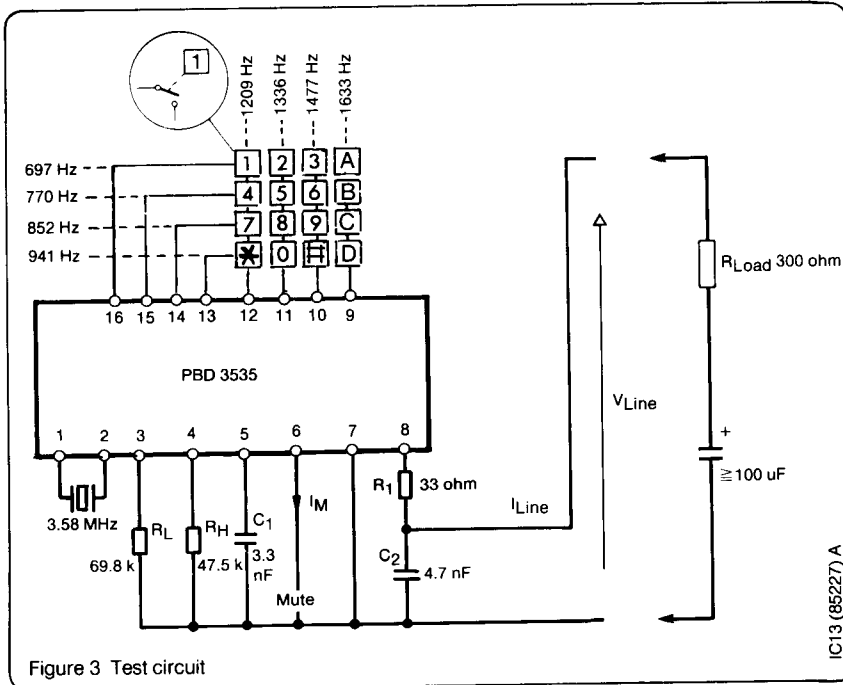


Figure 3 Test circuit

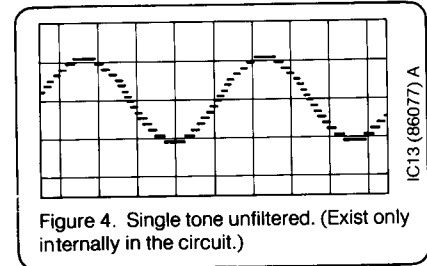


Figure 4. Single tone unfiltered. (Exist only internally in the circuit.)

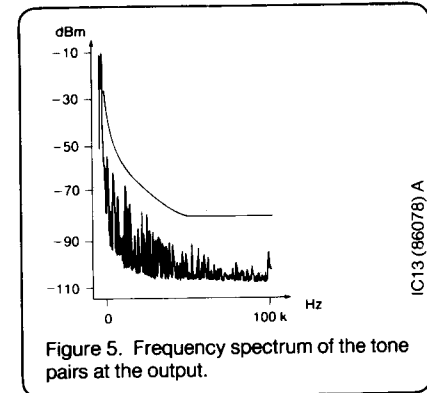


Figure 5. Frequency spectrum of the tone pairs at the output.

The circuit generates through digital synthesis the 8-tones which are needed for DTMF-signalling on a telephone line. A 3.5795 MHz TV crystal is used as frequency standard.

The crystal oscillator frequency is divided first by 4 and then by 7 for the low frequency group and by 5 for the high frequency group.

The generation of the two tones which signify the specific digit is activated by connecting one input in one group to

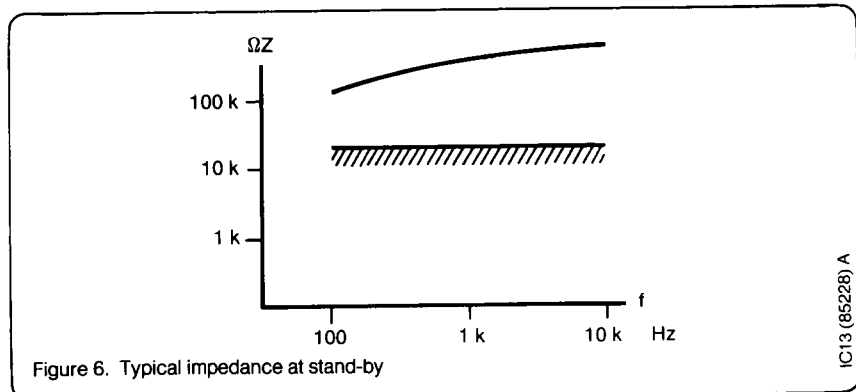


Figure 6. Typical impedance at stand-by

an input in the other group. Each tone is generated digitally with I^2L logic. Each digital signal is fed into a 4-bit digital/analog converter that generates a sinusshaped signal 15 steps in amplitude and 30 steps in time for each cycle.

The steplength is varied for each step but also for each tone to obtain a sinus signal with as low overtone content as possible and using as simple filter as possible. The result is according to the CEPT specification.

Reference to the signal amplitude is a band gap-reference voltage of 1.22 V. The additive signal from the two D/A converters is filtered in an internal filter and after that in an external filterstage.

The signal is fed into the output amplifier and directly to the telephone line. The output amplifier that is a current generator, generates the output signal to the line as a current and has a high output impedance.

The circuit is powered by current generators from the +line and most of it is switched on first when the circuit is activated. The keyboard is sensed by DC-currents which gives good possibilities to use effective RFI suppression methods.

If two or more keys are pressed, no tones other than the basic eight are generated.

All tones can be generated separately. When testing a circuit by connecting one input from the high frequency group to one input in the low frequency group plus shorting pin 3 or pin 4 to ground pin 7, one single tone is generated (high and low frequency, respectively).

The absolute signal levels can be adjusted with R_L and R_H , but there is no need for individual adjustment on every circuit. The signal level is stabilized against variations in temperature and line current.

Pause time and signal time are determined externally from the keyboard.

Allowed leakage in keyboard 1 Mohm. Typical thresholds is 100 k Ω .

The circuit is made to work properly with electronic speech circuits such as RIFAs PBL 3726 or PBL 3781.

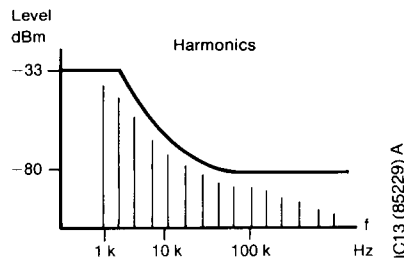


Figure 7. Typical harmonics suppression

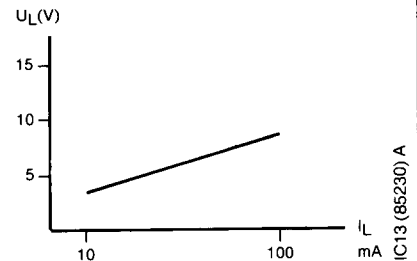


Figure 8. DC characteristics with speech circuit PBL 3726/6.

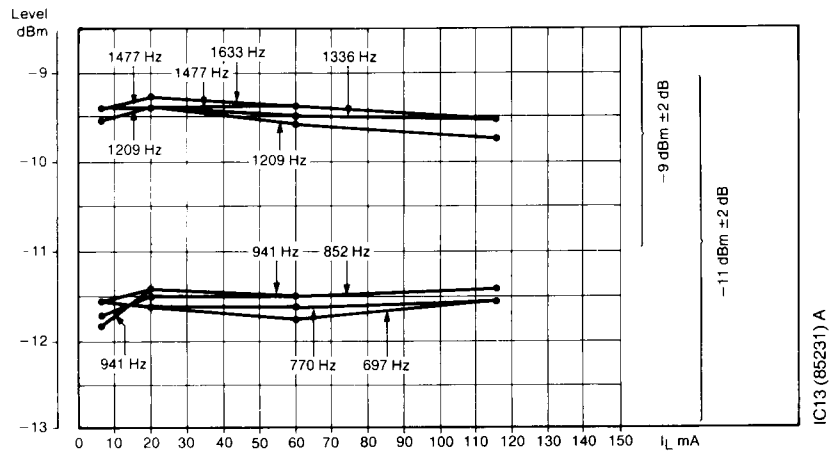


Figure 9. Tone level vs line current according to figure 3.

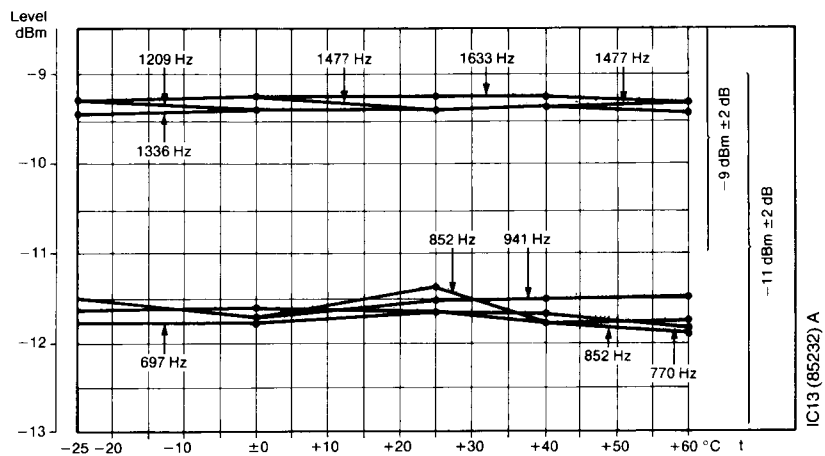


Figure 10. Tone level vs temperature

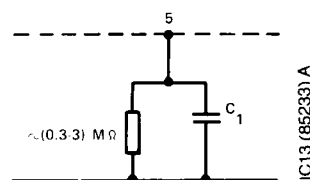


Figure 11.

Component function:

- R₁: Protecting resistor
- R_L: Signal level (low)
- R_H: Signal level (high)
- C₁: Low pass filter
- C₂: Radio frequency suppression (if used together with speech circuit with radio suppression already included in the external components, like PBL 3726, C₂ is not necessary).

To find suitable resistor values for R_H and R_L to get the desired tone levels the following formula can be used for a preliminary calculation. Please note that in R_{LOAD} (f = 1.4 kHz) and R_{LOAD} (f = 800 Hz) both the impedance of the line and the impedance of the speech circuit are included. U_{High} and U_{Low} are the desired high and low frequency levels, in dBm.

$$R_{High} = 56.2 \times R_{LOAD} (f = 1.4 \text{ kHz})$$

$$\times 10^{-\frac{U_{High}}{20}}$$

$$R_{Low} = 65.6 \times R_{LOAD} (f = 800 \text{ Hz})$$

$$\times 10^{-\frac{U_{Low}}{20}}$$

The current consumption within PBD 3535 can be reduced with a resistor connected in parallel with C₁ (see fig 9). If the current reduction is made too large, the output signal will be distorted by clipping.

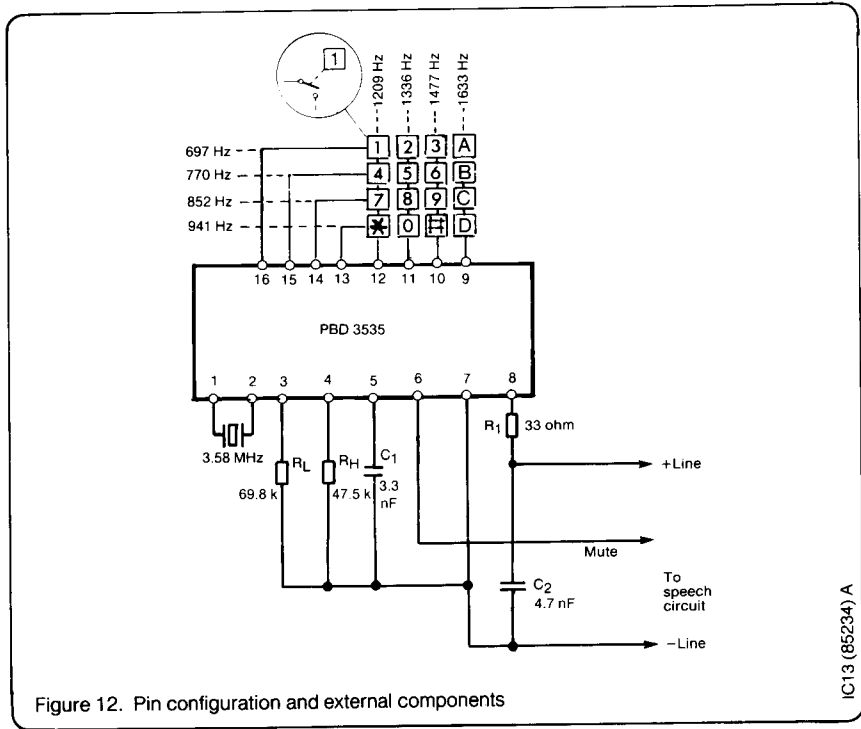


Figure 12. Pin configuration and external components

IC13 (85234) A

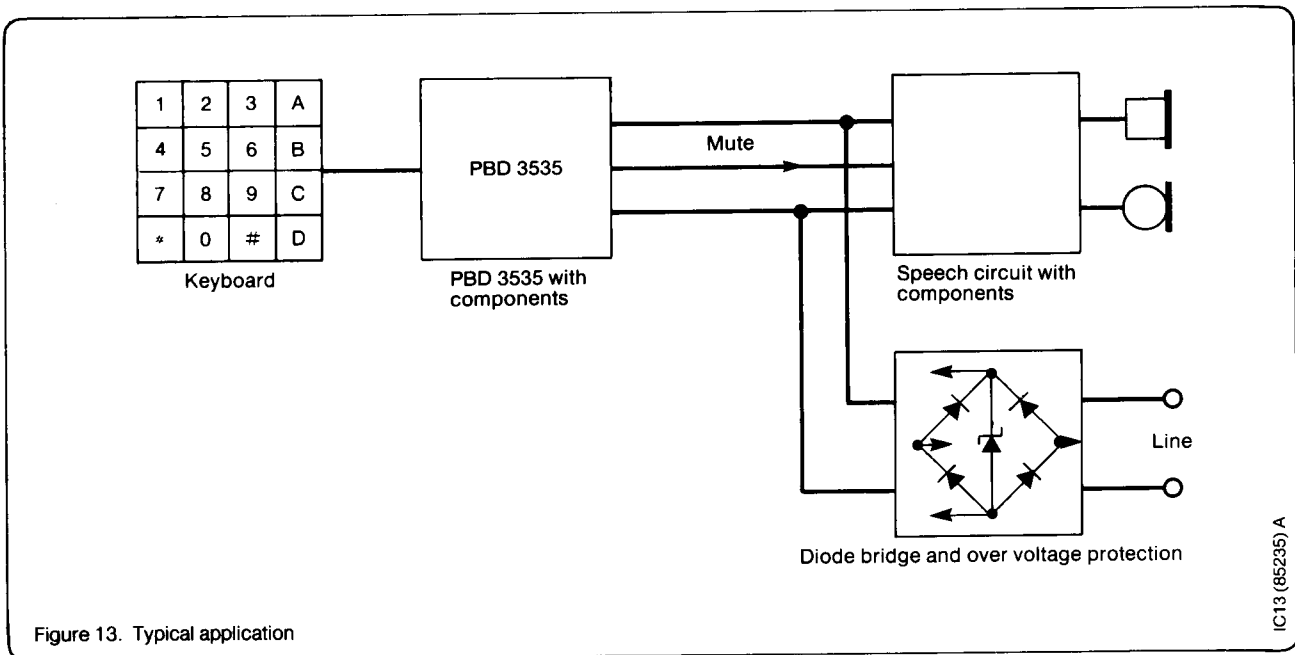


Figure 13. Typical application

IC13 (85235) A

In applications where a DTMF generator directly powered from the telephone line is wanted (the generator is not working in parallel with any kind of speech network), PBD 3535 can be used with a DC regulator as described in fig 14.

These schematics give a DC regulator for the range 16–100 mA with an output impedance that is a compromise between 600 ohm and 900 ohm in parallel with 30 nF. The zener diode is used to ensure a fast start-up time.

For telephone systems with voltage supply (instead of current supply) for the telephone line and where the telephone set is supposed to work as a current source, PBD 3535 can be connected with a series regulator as shown in fig 15.

These schematics are working in the area 5–36 V and the output impedance is matched against 600 ohm.

PBD 3535 can also be controlled by a microprocessor (see fig 16). The negative branch of the microprocessor voltage supply is connected to pin 7 of PBD 3535 and the inputs (8) are connected with resistors. For tone-generating one input of the low group (pins 13–16) is high and one input of the high group (pins 9–12) is low. When an input of the high group (pins 9–12) is low, PBD 3535 is activated and the mute output is put in high state.

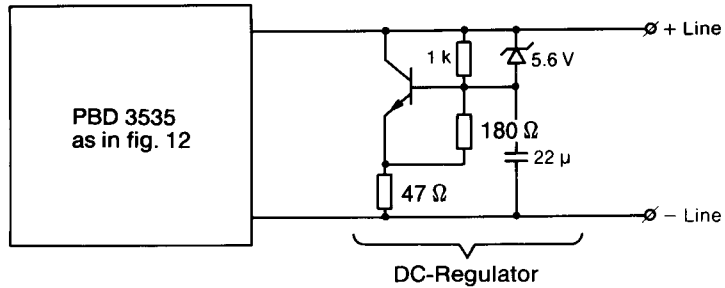


Figure 14. DC-regulator schematics

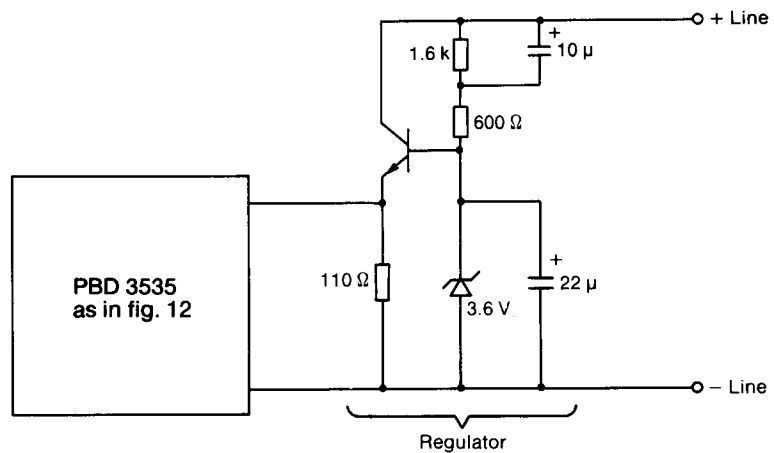


Figure 15. Current regulator

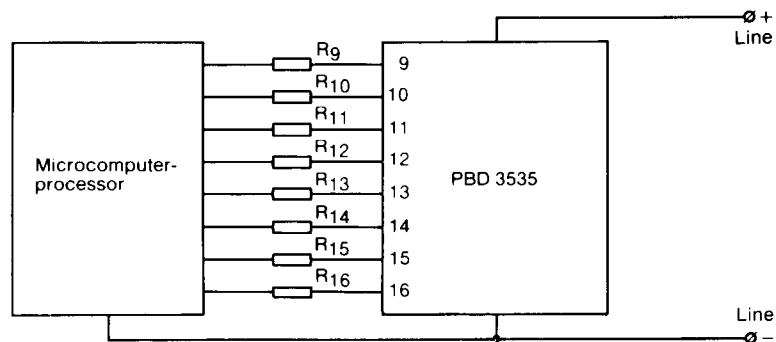


Figure 16. Microcomputer interface

The resistors R₉, R₁₀, R₁₁ and R₁₂ have two functions.

- When at low input level, ensure that the input does not get below +0.2 V. This must not occur.
- When the input level is high, limit the current. Too high current will interfere with the functions of the other three inputs (the resistors can be exchanged with diodes in direction away from PBD 3535).

Example: The logic states vary from 0 V to +3 V. Suitable resistor value is 27 kohm (see fig 17).

The two functions of the resistors R₁₃, R₁₄, R₁₅ and R₁₆ are:

- To raise the OFF/ON voltage
- To limit the current when the input levels are high

Example: The logic states vary from 0 V to +3 V. Suitable resistor value is 68 kohm (see fig 18).

In some telephone instrument designs a click can be heard in the receiver when a button is pressed down for tone signalling. In some applications this has been found desirable as a feedback but in others the effect is not so desirable. To suppress the click effect an RC network as seen in fig 19 can be applied. A capacitor of 47 nF halves the loudness of the click and a capacitor of 4.7 μF totally cancels the click effect (see fig 20).

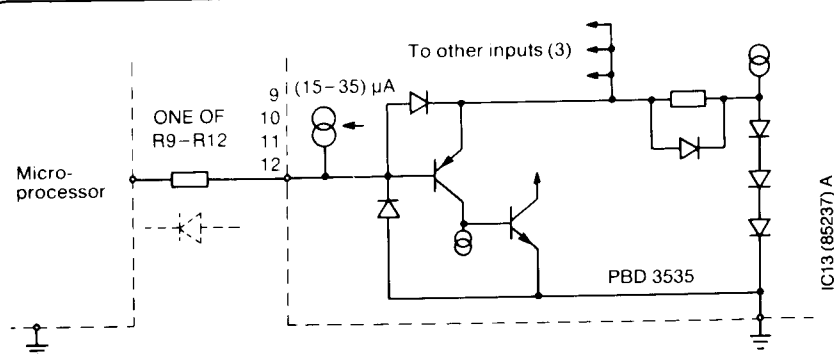


Figure 17. High frequency group resistors to microcomputer

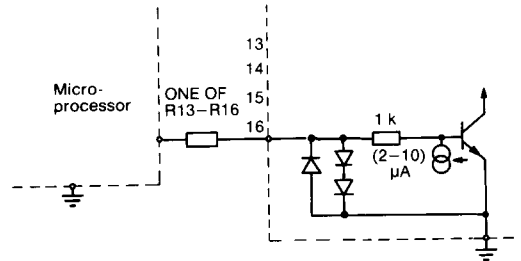


Figure 18. Low frequency group resistors to microcomputer

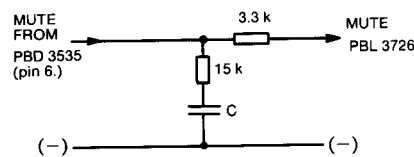


Figure 19. Click suppression

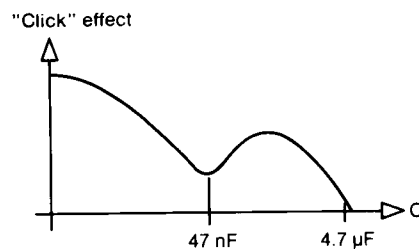


Figure 20. Click effect in relative sound pressure

IC13 (85237) A

IC13 (85238) A

IC13 (85241) A

IC13 (85242) A

Mechanical Data

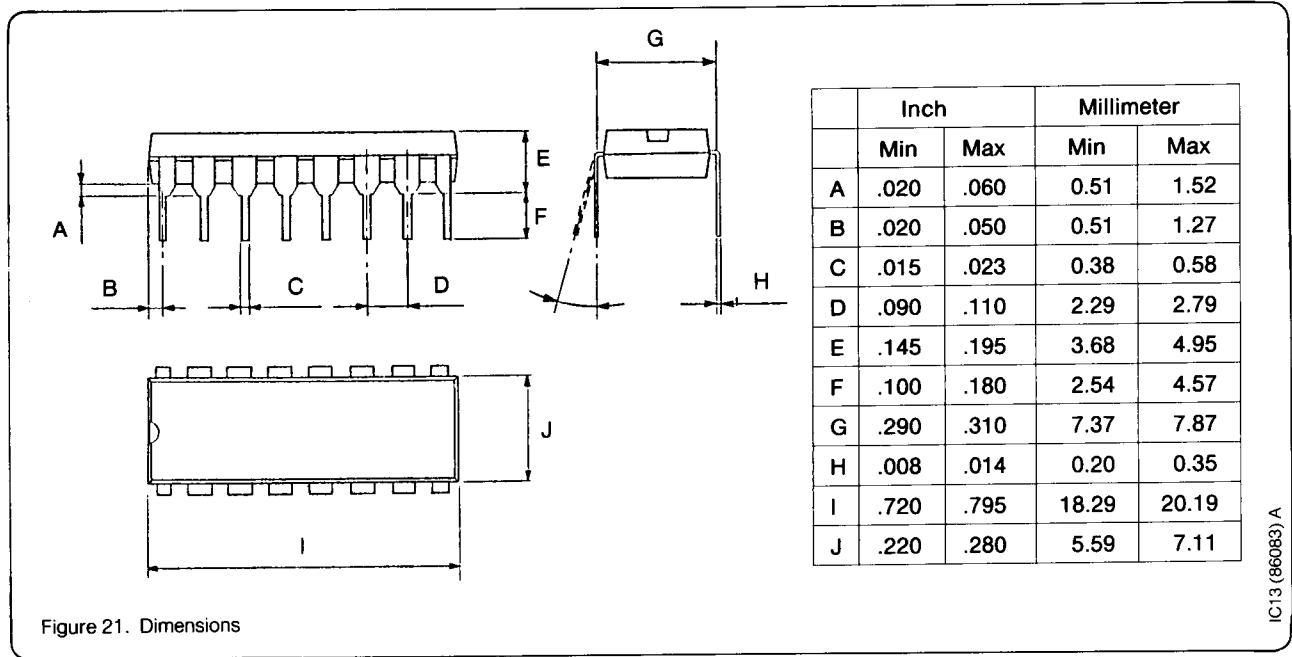


Figure 21. Dimensions

Ordering information

| | | |
|---------------|----------------|---------------|
| RIFA type No. | Function | Encapsulation |
| PBD 3535 | DTMF-Generator | 16 Pin DIP |

