

# DATA SHEET

**TEA6323T**

Sound fader control circuit

Preliminary specification  
File under Integrated Circuits, IC01

1995 Dec 20

## Sound fader control circuit

TEA6323T

## FEATURES

- Source selector for three stereo and one differential stereo input for remote sources
- The differential stereo input works optional as a fourth stereo input and the common mode pin can be used as well as an additional mono input
- Interface for noise reduction circuits
- Interface for external equalizer
- Volume, balance and fader control
- Output at volume I for external booster
- Special loudness characteristic automatically controlled in combination with volume setting
- Bass control with equalizer filters
- Treble control
- Mute control at audio signal zero crossing
- Logic output to read mute status
- Fast mute control via I<sup>2</sup>C-bus



- Fast mute control via pin
- I<sup>2</sup>C-bus control for all functions
- Power supply with internal power-on reset
- Power down indication.

## GENERAL DESCRIPTION

The sound fader control circuit TEA6323T is an I<sup>2</sup>C-bus controlled stereo preamplifier for car radio hi-fi sound applications.

## QUICK REFERENCE DATA

| SYMBOL                    | PARAMETER                                             | CONDITIONS                                                      | MIN. | TYP. | MAX. | UNIT |
|---------------------------|-------------------------------------------------------|-----------------------------------------------------------------|------|------|------|------|
| V <sub>CC</sub>           | supply voltage                                        |                                                                 | 7.5  | 8.5  | 9.5  | V    |
| I <sub>CC</sub>           | supply current                                        | V <sub>CC</sub> = 8.5 V                                         | –    | 26   | –    | mA   |
| V <sub>o(rms)</sub>       | maximum output voltage level                          | V <sub>CC</sub> = 8.5 V; THD ≤ 0.1%                             | –    | 2000 | –    | mV   |
| G <sub>v</sub>            | voltage gain                                          |                                                                 | –86  | –    | +20  | dB   |
| G <sub>step(vol)</sub>    | step resolution (volume)                              |                                                                 | –    | 1    | –    | dB   |
| G <sub>bass</sub>         | bass control                                          |                                                                 | –18  | –    | +18  | dB   |
| G <sub>treble</sub>       | treble control                                        |                                                                 | –12  | –    | +12  | dB   |
| G <sub>step(treble)</sub> | step resolution (treble)                              |                                                                 | –    | 1.5  | –    | dB   |
| (S+N)/N                   | signal-plus-noise to noise ratio                      | V <sub>O</sub> = 2.0 V; G <sub>v</sub> = 0 dB; unweighted       | –    | 105  | –    | dB   |
| RR <sub>100</sub>         | ripple rejection                                      | V <sub>r(rms)</sub> < 200 mV; f = 100 Hz; G <sub>v</sub> = 0 dB | –    | 75   | –    | dB   |
| CMRR                      | common mode rejection ratio differential stereo input |                                                                 | 43   | 53   | –    | dB   |

## ORDERING INFORMATION

| TYPE NUMBER | PACKAGE |                                              |          |
|-------------|---------|----------------------------------------------|----------|
|             | NAME    | DESCRIPTION                                  | VERSION  |
| TEA6323T    | VSO40   | plastic very small outline package; 40 leads | SOT158-1 |

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## BLOCK DIAGRAM

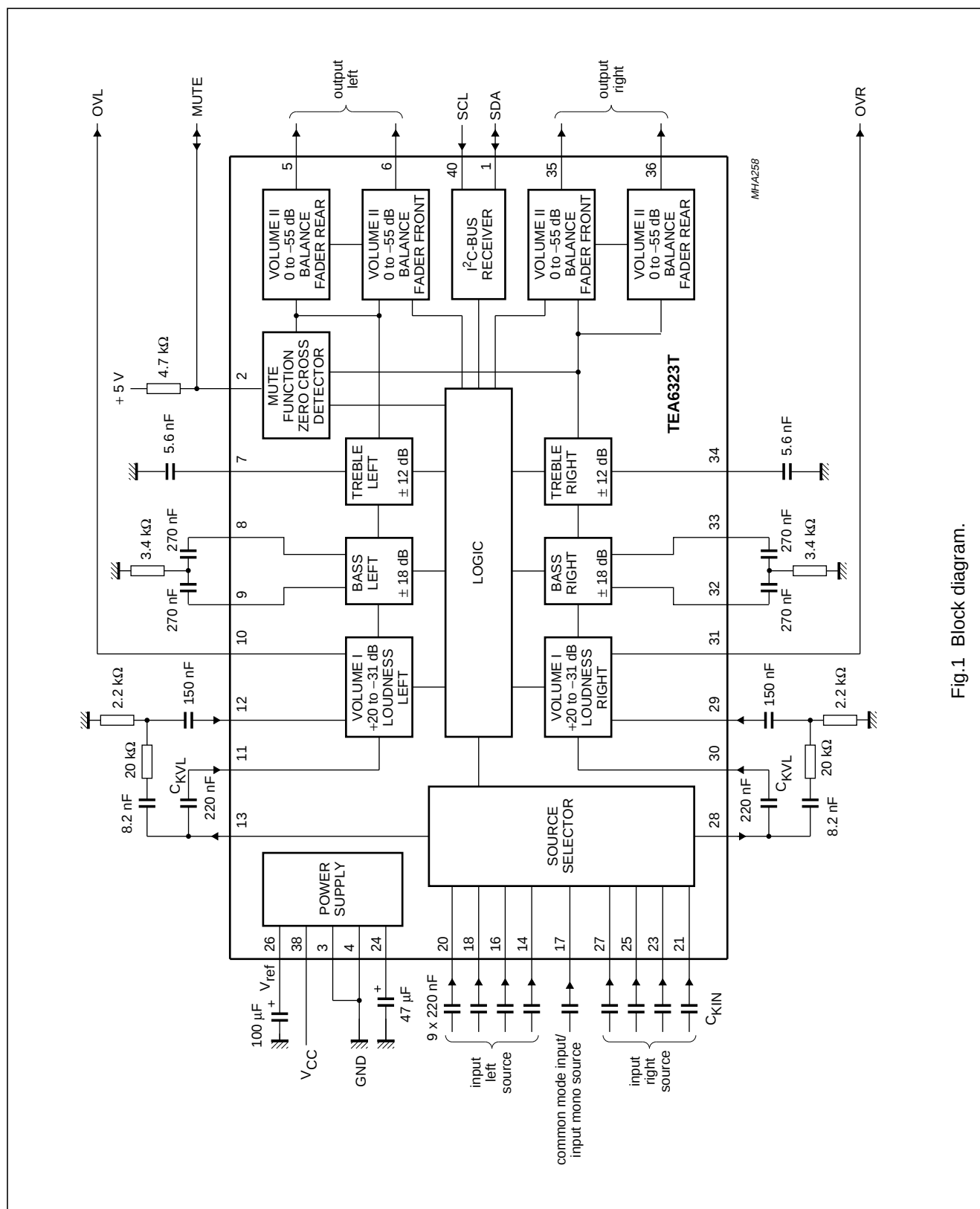


Fig.1 Block diagram.

## Sound fader control circuit

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## PINNING

| SYMBOL           | PIN | DESCRIPTION                                                                |
|------------------|-----|----------------------------------------------------------------------------|
| SDA              | 1   | serial data input/output                                                   |
| MUTE             | 2   | mute control input and output                                              |
| DGND             | 3   | digital ground                                                             |
| AGND             | 4   | analog ground                                                              |
| OUTLR            | 5   | output left rear                                                           |
| OUTLF            | 6   | output left front                                                          |
| TL               | 7   | treble control capacitor left channel or input from an external equalizer  |
| B2L              | 8   | bass control left channel or output to an external equalizer               |
| B1L              | 9   | bass control, left channel                                                 |
| OVL              | 10  | output volume I, left channel                                              |
| IVL              | 11  | input volume I, left control part                                          |
| ILL              | 12  | input loudness, left control part                                          |
| QSL              | 13  | output source selector, left channel                                       |
| IDL              | 14  | input D left source                                                        |
| i.c.             | 15  | COMM, common mode rejection adjust, centre position                        |
| ICL              | 16  | input C left source                                                        |
| COM              | 17  | common mode input / mono source input                                      |
| IBL              | 18  | input B left source                                                        |
| i.c.             | 19  | COML, common mode rejection adjust, left position                          |
| IAL              | 20  | input A differential source left                                           |
| IAR              | 21  | input A differential source right                                          |
| i.c.             | 22  | COMR, common mode rejection adjust, right position                         |
| IBR              | 23  | input B right source                                                       |
| CAP              | 24  | electronic filtering for supply                                            |
| ICR              | 25  | input C right source                                                       |
| V <sub>ref</sub> | 26  | reference voltage (0.5V <sub>CC</sub> )                                    |
| IDR              | 27  | input D right source                                                       |
| QSR              | 28  | output source selector right channel                                       |
| ILR              | 29  | input loudness right channel                                               |
| IVR              | 30  | input volume I, right control part                                         |
| OVR              | 31  | output volume I, right channel                                             |
| B1R              | 32  | bass control right channel                                                 |
| B2R              | 33  | bass control right channel or output to an external equalizer              |
| TR               | 34  | treble control capacitor right channel or input from an external equalizer |
| OUTRF            | 35  | output right front                                                         |
| OUTRR            | 36  | output right rear                                                          |
| n.c.             | 37  | not connected                                                              |
| V <sub>CC</sub>  | 38  | supply voltage                                                             |
| n.c.             | 39  | not connected                                                              |
| SCL              | 40  | serial clock input                                                         |

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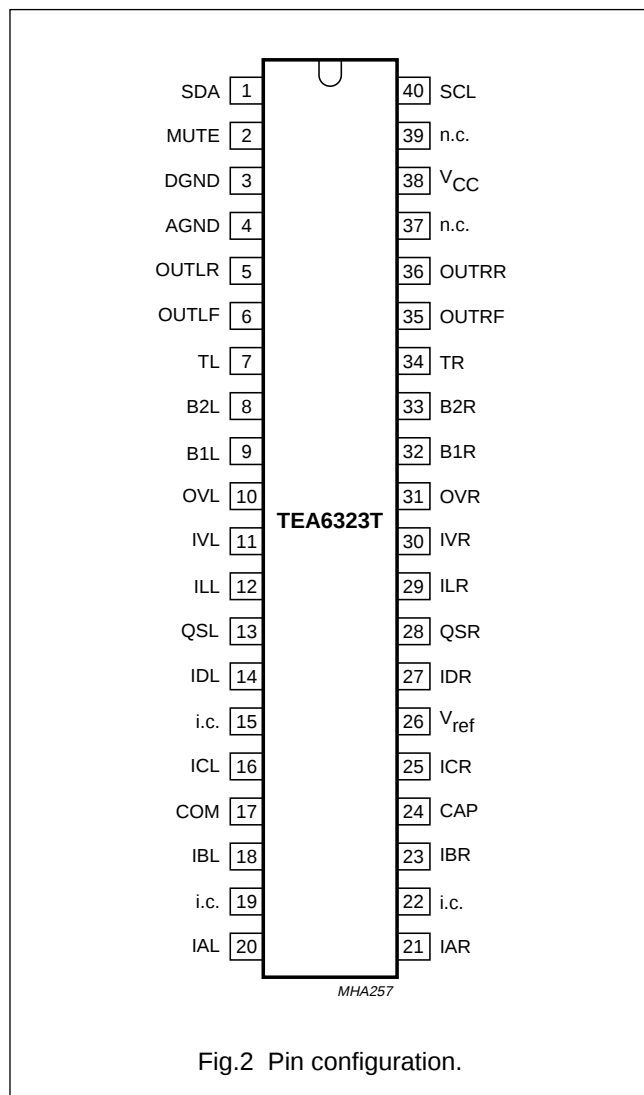


Fig.2 Pin configuration.

## FUNCTIONAL DESCRIPTION

The source selector allows either the source selection between the differential stereo input (IAL, IAR and COM) and three stereo inputs, or selection of four stereo inputs and the mono input (COM). The maximum input signal voltage is  $V_{i(rms)} = 2$  V. The outputs of the source selector and the inputs of the following volume control parts are available at pins 13 and 11 for the left channel and pins 28 and 30 for the right channel. This offers the possibility of interfacing a noise reduction system.

The volume control part is following the source selector. The signal phase from input volume control part to all outputs is  $180^\circ$ .

The volume control function is split into two sections: volume I control block and volume II control block.

The control range of volume I is between +20 dB and -31 dB in steps of 1 dB. The volume II control range is between 0 dB and -55 dB in steps of 1 dB. Although the theoretical possible control range is 106 dB (+20 to -86 dB), in practice a range of 86 dB (+20 to -66 dB) is recommended. The gain/attenuation setting of the volume I control block is common for both channels.

The volume I control block operates in combination with the loudness control. The filter is linear when the maximum gain for the volume I control (+20 dB) is selected. The filter characteristic increases automatically over a range of 32 dB down to a setting of -12 dB. That means the maximum filter characteristic is obtained at -12 dB setting of volume I. Further reduction of the volume does not further influence the filter characteristic (see Fig.5). The maximum selected filter characteristic is determined by external components. The proposed application gives a maximum boost of 17 dB for bass and 4.5 dB for treble. The loudness may be switched on or off via I<sup>2</sup>C-bus control (see Table 7).

The volume I control block has an output pin and is followed by the bass control block. An external filter for each channel in combination with internal resistors, provides the frequency response of the bass control (see Fig.3). The adjustable range is between -18 and +18 dB in steps of 1.8 dB at 46 Hz.

Both, loudness and bass control result in a maximum bass boost of 35 dB for low volume settings.

The treble control block offers a control range between -12 and +12 dB in steps of 1.5 dB at 15 kHz. The filter characteristic is determined by a single capacitor of 5.6 nF for each channel in combination with internal resistors (see Fig.4).

The basic step width of treble control is 3 dB. The intermediate steps are obtained by switching 1.5 dB boost and 1.5 dB attenuation steps.

The bass and treble control functions can be switched off via I<sup>2</sup>C-bus. In this event the internal signal flow is disconnected. The connections B2L and B2R are outputs and TL and TR are inputs for inserting an external equalizer.

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The last section of the circuit is the volume II block. The balance and fader functions are performed using the same control blocks. This is realized by 4 independently controllable attenuators, one for each output. The control range of these attenuators is 55 dB in steps of 1 dB with an additional mute step.

The circuit provides 3 mute modes:

1. Zero crossing mode mute via I<sup>2</sup>C-bus using 2 independent zero crossing detectors (ZCM, see Tables 2 and 9).
2. Fast mute via MUTE pin.
3. Fast mute via I<sup>2</sup>C-bus either by general mute (GMU, see Tables 2 and 9) or volume II block setting (see Table 4).

The mute function is performed immediately if ZCM is cleared (ZCM = 0). If the bit is set (ZCM = 1) the mute is activated after changing the GMU bit. The actual mute switching is delayed until the next zero crossing of the audio frequency signal. As the two audio channels (left and right) are independent, two comparators are built-in to control independent mute switches.

To avoid a large delay of mute switching when very low frequencies are processed or the output signal amplitude is lower than the DC offset voltage a second I<sup>2</sup>C-bus transmission is needed. Both transmissions have the same data and the second transmission a delay time of e.g. 100 ms. The first transmission starts the zero cross circuit, but second transmission moves the mute switch immediately if the circuit has no zero cross detected.

The mute function can also be controlled externally. If the mute pin is switched to ground all outputs are muted immediately (except the outputs volume left and right (OVL and OVR) and hardware mute). This mute request overwrites all mute controls via the I<sup>2</sup>C-bus for the time the pin is held LOW. The hardware mute position is not stored in the TEA6323T.

The mute pin can also be used as output. The mute pin voltage is low when all outputs are in mute position.

For the turn on/off behaviour the following explanation is generally valid. To avoid AF output caused by the input signal coming from preceding stages, which produces output during drop of V<sub>CC</sub>, the mute has to be set, before the V<sub>CC</sub> will drop. This can be achieved by I<sup>2</sup>C-bus control or by grounding the MUTE pin.

For use where is no mute in the application before turn off, a supply voltage drop of more than  $1 \times V_{BE}$  will result in a mute during the voltage drop.

The power supply should include a V<sub>CC</sub> buffer capacitor, which provides a discharging time constant. If the input signal does not disappear after turn off the input will become audible after certain time. A 4.7 kΩ resistor discharges the V<sub>CC</sub> buffer capacitor, because the internal current of the IC does not discharge it completely.

The hardware mute function is favourable for use in Radio Data System (RDS) applications. The zero crossing mute avoids modulation pops. This feature is an advantage for mute during changing presets and/or sources (e.g. traffic announcement during cassette playback).

### LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

| SYMBOL           | PARAMETER                                        | CONDITIONS | MIN. | MAX.            | UNIT |
|------------------|--------------------------------------------------|------------|------|-----------------|------|
| V <sub>CC</sub>  | supply voltage                                   |            | 0    | 10              | V    |
| V <sub>n</sub>   | voltage at pins 1, 2 and 5 to 40 to pins 3 and 4 |            | 0    | V <sub>CC</sub> | V    |
| T <sub>amb</sub> | operating ambient temperature                    |            | −40  | +85             | °C   |
| T <sub>stg</sub> | storage temperature                              |            | −65  | +150            | °C   |
| V <sub>es</sub>  | electrostatic handling                           | note 1     |      |                 |      |

### Note

1. Human body model: C = 100 pF; R = 1.5 kΩ; V ≥ 2 kV. Charge device model: C = 200 pF; R = 0 Ω; V ≥ 500 V.

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**CHARACTERISTICS**

$V_{CC} = 8.5\text{ V}$ ;  $R_S = 600\ \Omega$ ;  $R_L = 10\text{ k}\Omega$ ;  $C_L = 2.5\text{ nF}$ ; AC coupled;  $f = 1\text{ kHz}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; gain control  $G_V = 0\text{ dB}$ ; bass linear; treble linear; fader off; balance in mid position; loudness off; unless otherwise specified.

| SYMBOL        | PARAMETER                                                                      | CONDITIONS                                                                                             | MIN.  | TYP. | MAX. | UNIT |
|---------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-------|------|------|------|
| $V_{CC}$      | supply voltage                                                                 |                                                                                                        | 7.5   | 8.5  | 9.5  | V    |
| $I_{CC}$      | supply current                                                                 |                                                                                                        | –     | 26   | 33   | mA   |
| $V_{DC}$      | internal DC voltage at inputs and outputs                                      |                                                                                                        | 3.83  | 4.25 | 4.68 | V    |
| $V_{ref}$     | internal reference voltage at pin 26                                           |                                                                                                        | –     | 4.25 | –    | V    |
| $G_{V(max)}$  | maximum voltage gain                                                           | $R_S = 0\ \Omega$ ; $R_L = \infty$                                                                     | 19    | 20   | 21   | dB   |
| $V_{o(rms)}$  | output voltage level for $P_{max}$ at the power output stage start of clipping | THD $\leq 0.5\%$ ; see Fig.10                                                                          | –     | 2000 | –    | mV   |
|               |                                                                                | THD = 1%; $G_V = 3\text{ dB}$                                                                          | 2300  | –    | –    | mV   |
|               |                                                                                | $R_L = 2\text{ k}\Omega$ ; $C_L = 10\text{ nF}$ ; THD = 1%                                             | 2000  | –    | –    | mV   |
|               |                                                                                |                                                                                                        |       |      |      |      |
| $V_{i(rms)}$  | input sensitivity                                                              | $V_o = 2000\text{ mV}$ ; $G_V = 20\text{ dB}$                                                          | –     | 200  | –    | mV   |
| $f_{ro}$      | roll-off frequency                                                             | $C_{KIN} = 220\text{ nF}$ ;<br>$C_{KVL} = 220\text{ nF}$ ; $Z_i = Z_{i(min)}$                          |       |      |      |      |
|               |                                                                                | low frequency (–1 dB)                                                                                  | 60    | –    | –    | Hz   |
|               |                                                                                | low frequency (–3 dB)                                                                                  | 30    | –    | –    | Hz   |
|               |                                                                                | high frequency (–1 dB)                                                                                 | 20000 | –    | –    | Hz   |
|               |                                                                                | $C_{KIN} = 470\text{ nF}$ ;<br>$C_{KVL} = 100\text{ nF}$ ; $Z_i = Z_{i(typ)}$<br>low frequency (–3 dB) | 17    | –    | –    | Hz   |
| $\alpha_{cs}$ | channel separation                                                             | $V_i = 2\text{ V}$ ; frequency range 250 Hz to 10 kHz                                                  | 74    | 80   | –    | dB   |
| THD           | total harmonic distortion                                                      | frequency range 20 Hz to 12.5 kHz                                                                      |       |      |      |      |
|               |                                                                                | $V_i = 100\text{ mV}$ ; $G_V = 20\text{ dB}$                                                           | –     | 0.1  | –    | %    |
|               |                                                                                | $V_i = 1\text{ V}$ ; $G_V = 0\text{ dB}$                                                               | –     | 0.05 | 0.1  | %    |
|               |                                                                                | $V_i = 2\text{ V}$ ; $G_V = 0\text{ dB}$                                                               | –     | 0.1  | –    | %    |
|               |                                                                                | $V_i = 2\text{ V}$ ; $G_V = -10\text{ dB}$                                                             | –     | 0.1  | –    | %    |
| RR            | ripple rejection                                                               | $V_{r(rms)} < 200\text{ mV}$                                                                           |       |      |      |      |
|               |                                                                                | $f = 100\text{ Hz}$                                                                                    | 70    | 76   | –    | dB   |
|               |                                                                                | $f = 40\text{ Hz to }12.5\text{ kHz}$                                                                  | –     | 66   | –    | dB   |

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| SYMBOL                                                                                        | PARAMETER                                                                                                      | CONDITIONS                                                                  | MIN. | TYP. | MAX. | UNIT       |
|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|------|------|------|------------|
| (S+N)/N                                                                                       | signal-plus-noise to noise ratio                                                                               | unweighted;<br>20 Hz to 20 kHz (RMS);<br>$V_o = 2.0$ V;<br>see Figs 6 and 7 | –    | 105  | –    | dB         |
|                                                                                               |                                                                                                                | CCIR468-2 weighted;<br>quasi peak; $V_o = 2.0$ V                            |      |      |      |            |
|                                                                                               |                                                                                                                | $G_v = 0$ dB                                                                | –    | 95   | –    | dB         |
|                                                                                               |                                                                                                                | $G_v = 12$ dB                                                               | –    | 88   | –    | dB         |
|                                                                                               |                                                                                                                | $G_v = 20$ dB                                                               | –    | 81   | –    | dB         |
|                                                                                               | differential input                                                                                             | $G_v = 0$ dB                                                                | –    | 90   | –    | dB         |
|                                                                                               |                                                                                                                | $G_v = 20$ dB                                                               | –    | 79   | –    | dB         |
| CMRR                                                                                          | common mode rejection ratio<br>differential stereo input                                                       |                                                                             | 43   | 53   | –    | dB         |
| $P_{no(rms)}$                                                                                 | noise output power (RMS value)<br>only contribution of TEA6323T;<br>power amplifier for 6 W                    | mute position; note 1                                                       | –    | –    | 10   | nW         |
| $\alpha_{ct}$                                                                                 | crosstalk<br>$\left( 20 \log \frac{V_{bus(p-p)}}{V_{o(rms)}} \right)$ between bus<br>inputs and signal outputs | note 2                                                                      | –    | 110  | –    | dB         |
| <b>Source selector</b>                                                                        |                                                                                                                |                                                                             |      |      |      |            |
| $Z_i$                                                                                         | input impedance                                                                                                |                                                                             | 25   | 35   | 45   | k $\Omega$ |
| $\alpha_S$                                                                                    | input isolation of one selected<br>source to any other input                                                   | $f = 1$ kHz                                                                 | –    | 105  | –    | dB         |
|                                                                                               |                                                                                                                | $f = 12.5$ kHz                                                              | –    | 95   | –    | dB         |
| $V_{i(rms)}$                                                                                  | maximum input voltage<br>(RMS value)                                                                           | THD < 0.5%; $V_{CC} = 8.5$ V                                                | –    | 2.15 | –    | V          |
|                                                                                               |                                                                                                                | THD < 0.5%; $V_{CC} = 7.5$ V                                                | –    | 1.8  | –    | V          |
| $V_{offset}$                                                                                  | DC offset voltage at source selector<br>output                                                                 |                                                                             |      |      |      |            |
|                                                                                               | by selection of any stereo inputs                                                                              |                                                                             | –    | –    | 10   | mV         |
|                                                                                               | by selection of differential input or<br>mono input                                                            |                                                                             | –    | –    | 20   | mV         |
| $Z_o$                                                                                         | output impedance                                                                                               |                                                                             | –    | 80   | 120  | $\Omega$   |
| $R_L$                                                                                         | output load resistance                                                                                         |                                                                             | 10   | –    | –    | k $\Omega$ |
| $C_L$                                                                                         | output load capacity                                                                                           |                                                                             | 0    | –    | 2500 | pF         |
| $G_v$                                                                                         | voltage gain, source selector                                                                                  |                                                                             | –    | 0    | –    | dB         |
| <b>Control part (source selector disconnected; source resistance 600 <math>\Omega</math>)</b> |                                                                                                                |                                                                             |      |      |      |            |
| $Z_i$                                                                                         | input impedance volume input                                                                                   |                                                                             | 100  | 150  | 200  | k $\Omega$ |
|                                                                                               | input impedance loudness input                                                                                 |                                                                             | 25   | 33   | 40   | k $\Omega$ |
| $Z_o$                                                                                         | output impedance                                                                                               |                                                                             | –    | 80   | 120  | $\Omega$   |
| $R_L$                                                                                         | output load resistance                                                                                         |                                                                             | 2    | –    | –    | k $\Omega$ |
| $C_L$                                                                                         | output load capacity                                                                                           |                                                                             | 0    | –    | 10   | nF         |

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| SYMBOL                        | PARAMETER                                    | CONDITIONS                                                                                                                           | MIN.                 | TYP.                      | MAX.                     | UNIT                     |
|-------------------------------|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------------------|--------------------------|--------------------------|
| V <sub>i(rms)</sub>           | maximum input voltage<br>(RMS value)         | THD < 0.5%                                                                                                                           | –                    | 2.15                      | –                        | V                        |
| V <sub>no</sub>               | noise output voltage                         | CCIR468-2 weighted;<br>quasi peak<br><br>G <sub>V</sub> = 20 dB<br>G <sub>V</sub> = 0 dB<br>G <sub>V</sub> = –66 dB<br>mute position | <br>–<br>–<br>–<br>– | <br>110<br>33<br>13<br>10 | <br>220<br>50<br>22<br>– | <br>μV<br>μV<br>μV<br>μV |
| CR <sub>tot</sub>             | total continuous control range               |                                                                                                                                      | –                    | 106                       | –                        | dB                       |
|                               | recommended control range                    |                                                                                                                                      | –                    | 86                        | –                        | dB                       |
| G <sub>step</sub>             | step resolution                              |                                                                                                                                      | –                    | 1                         | –                        | dB                       |
|                               | step error between any adjoining<br>step     |                                                                                                                                      | –                    | –                         | 0.5                      | dB                       |
| ΔG <sub>a</sub>               | attenuator set error                         | G <sub>V</sub> = +20 to –50 dB                                                                                                       | –                    | –                         | 2                        | dB                       |
|                               |                                              | G <sub>V</sub> = –51 to –66 dB                                                                                                       | –                    | –                         | 3                        | dB                       |
| ΔG <sub>t</sub>               | gain tracking error                          | G <sub>V</sub> = +20 to –50 dB                                                                                                       | –                    | –                         | 2                        | dB                       |
| MUTE <sub>att</sub>           | mute attenuation                             | see Fig.9                                                                                                                            | 100                  | 110                       | –                        | dB                       |
| V <sub>offset</sub>           | DC step offset between any<br>adjoining step | G <sub>V</sub> = 0 to –66 dB                                                                                                         | –                    | 0.2                       | 10                       | mV                       |
|                               |                                              | G <sub>V</sub> = 20 to 0 dB                                                                                                          | –                    | 2                         | 15                       | mV                       |
|                               | DC step offset between any step to<br>mute   | G <sub>V</sub> = 0 to –66 dB                                                                                                         | –                    | –                         | 10                       | mV                       |
|                               |                                              | G <sub>V</sub> = 20 to 0 dB                                                                                                          | –                    | –                         | 40                       | mV                       |
|                               |                                              | G <sub>V</sub> = 0 to –31 dB;<br>loudness on                                                                                         | –                    | –                         | 17                       | mV                       |
| Volume I control and loudness |                                              |                                                                                                                                      |                      |                           |                          |                          |
| CR <sub>vol</sub>             | continuous volume control range              |                                                                                                                                      | –                    | 51                        | –                        | dB                       |
| G <sub>V</sub>                | voltage gain                                 |                                                                                                                                      | –31                  | –                         | +20                      | dB                       |
| G <sub>step</sub>             | step resolution                              |                                                                                                                                      | –                    | 1                         | –                        | dB                       |
| L <sub>Bmax</sub>             | maximum loudness boost                       | loudness on; referred to<br>loudness off; boost is<br>determined by external<br>components<br><br>f = 40 Hz<br><br>f = 10 kHz        |                      |                           |                          |                          |
|                               |                                              |                                                                                                                                      | –                    | 17                        | –                        | dB                       |
|                               |                                              | –                                                                                                                                    | 4.5                  | –                         | dB                       |                          |
| Bass control                  |                                              |                                                                                                                                      |                      |                           |                          |                          |
| G <sub>bass</sub>             | bass control, maximum boost                  | f = 46 Hz                                                                                                                            | 16                   | 18                        | 19                       | dB                       |
|                               | maximum attenuation                          | f = 46 Hz                                                                                                                            | 16                   | 18                        | 19                       | dB                       |
| G <sub>step</sub>             | step resolution (toggle switching)           | f = 46 Hz                                                                                                                            | –                    | 1.8                       | –                        | dB                       |
|                               | step error between any adjoining<br>step     | f = 46 Hz                                                                                                                            | –                    | –                         | 0.5                      | dB                       |
| V <sub>offset</sub>           | DC step offset in any bass position          |                                                                                                                                      | –                    | –                         | 20                       | mV                       |

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| SYMBOL                                                                                                                                  | PARAMETER                                             | CONDITIONS                                     | MIN. | TYP. | MAX.            | UNIT          |
|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------------------------------------------------|------|------|-----------------|---------------|
| <b>Treble control</b>                                                                                                                   |                                                       |                                                |      |      |                 |               |
| $G_{\text{treble}}$                                                                                                                     | treble control, maximum boost                         | $f = 15 \text{ kHz}$                           | 11   | 12   | 13              | dB            |
|                                                                                                                                         | maximum attenuation                                   | $f = 15 \text{ kHz}$                           | 11   | 12   | 13              | dB            |
|                                                                                                                                         | maximum boost                                         | $f > 15 \text{ kHz}$                           | –    | –    | 15              | dB            |
| $G_{\text{step}}$                                                                                                                       | step resolution (toggle switching)                    | $f = 15 \text{ kHz}$                           | –    | 1.5  | –               | dB            |
|                                                                                                                                         | step error between any adjoining step                 | $f = 15 \text{ kHz}$                           | –    | –    | 0.5             | dB            |
| $V_{\text{offset}}$                                                                                                                     | DC step offset in any treble position                 |                                                | –    | –    | 10              | mV            |
| <b>Volume II, balance and fader control</b>                                                                                             |                                                       |                                                |      |      |                 |               |
| CR                                                                                                                                      | continuous attenuation fader and volume control range |                                                | 53.5 | 55   | 56.5            | dB            |
| $G_{\text{step}}$                                                                                                                       | step resolution                                       |                                                | –    | 1    | 2               | dB            |
|                                                                                                                                         | attenuation set error                                 |                                                | –    | –    | 1.5             | dB            |
| <b>Mute function</b>                                                                                                                    |                                                       |                                                |      |      |                 |               |
| $V_{\text{muteLOWI}}$                                                                                                                   | input level for fast mute detection                   |                                                | –    | –    | 1.0             | V             |
|                                                                                                                                         | input level for no mute detection                     |                                                | 2.2  | –    | –               | V             |
| $V_{\text{muteLOWO}}$                                                                                                                   | output level for mute                                 | $I \leq 1 \text{ mA}; C_1 \leq 100 \text{ pF}$ | –    | –    | 0.4             | V             |
| $V_{\text{muteHIGH}}$                                                                                                                   | pull-up voltage                                       | open collector                                 | –    | –    | $V_{\text{CC}}$ | V             |
| $V_{\text{CCdrop}}$                                                                                                                     | supply drop to $V_{\text{CAP}}$ for mute active       |                                                | –    | –0.7 | –               | V             |
| <b>Power-on reset (when reset is active the GMU-bit (general mute) is set and the I<sup>2</sup>C-bus receiver is in reset position)</b> |                                                       |                                                |      |      |                 |               |
| $V_{\text{CC}}$                                                                                                                         | increasing supply voltage start of reset              |                                                | –    | –    | 2.5             | V             |
|                                                                                                                                         | end of reset                                          |                                                | 5.2  | 6.5  | 7.2             | V             |
|                                                                                                                                         | decreasing supply voltage start of reset              |                                                | 4.2  | 5.5  | 6.2             | V             |
| <b>Digital part (I<sup>2</sup>C-bus pins); note 3</b>                                                                                   |                                                       |                                                |      |      |                 |               |
| $V_{\text{iH}}$                                                                                                                         | HIGH level input voltage                              |                                                | 3    | –    | 9.5             | V             |
| $V_{\text{iL}}$                                                                                                                         | LOW level input voltage                               |                                                | –0.3 | –    | +1.5            | V             |
| $I_{\text{iH}}$                                                                                                                         | HIGH level input current                              | $V_{\text{CC}} = 0 \text{ to } 9.5 \text{ V}$  | –10  | –    | +10             | $\mu\text{A}$ |
| $I_{\text{iL}}$                                                                                                                         | LOW level input current                               |                                                | –10  | –    | +10             | $\mu\text{A}$ |
| $V_{\text{oL}}$                                                                                                                         | LOW level output voltage                              | $I_{\text{L}} = 3 \text{ mA}$                  | –    | –    | 0.4             | V             |

**Notes to the characteristics**

1. The indicated values for output power assume a 6 W power amplifier at 4  $\Omega$  with 20 dB gain and a fixed attenuator of 12 dB in front of it. Signal-to-noise ratios exclude noise contribution of the power amplifier.
2. The transmission contains: total initialization with MAD and subaddress for volume and 8 data words, see also definition of characteristics, clock frequency = 50 kHz, repetition burst rate = 400 Hz, maximum bus signal amplitude = 5 V (p-p).
3. The AC characteristics are in accordance with the I<sup>2</sup>C-bus specification. This specification, "The I<sup>2</sup>C-bus and how to use it", can be ordered using the code 9398 393 40011.

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**I<sup>2</sup>C-BUS PROTOCOL****I<sup>2</sup>C-bus format**

|                  |                              |                  |                           |                  |                     |                  |                  |
|------------------|------------------------------|------------------|---------------------------|------------------|---------------------|------------------|------------------|
| S <sup>(1)</sup> | SLAVE ADDRESS <sup>(2)</sup> | A <sup>(3)</sup> | SUBADDRESS <sup>(4)</sup> | A <sup>(3)</sup> | DATA <sup>(5)</sup> | A <sup>(3)</sup> | P <sup>(6)</sup> |
|------------------|------------------------------|------------------|---------------------------|------------------|---------------------|------------------|------------------|

**Notes**

1. S = START condition.
2. SLAVE ADDRESS (MAD) = 1000 0000.
3. A = acknowledge, generated by the slave.
4. SUBADDRESS (SAD), see Table 1.
5. DATA, see Table 1; if more than 1 byte of DATA is transmitted, then auto-increment of the significant subaddress is performed.
6. P = STOP condition.

**Table 1** Second byte after MAD

| FUNCTION          | BIT | MSB |   |   |   |   |                  |                  | LSB              |  |
|-------------------|-----|-----|---|---|---|---|------------------|------------------|------------------|--|
|                   |     | 7   | 6 | 5 | 4 | 3 | 2 <sup>(1)</sup> | 1 <sup>(1)</sup> | 0 <sup>(1)</sup> |  |
| Volume/loudness   | V   | 0   | 0 | 0 | 0 | 0 | 0                | 0                | 0                |  |
| Fader front right | FFR | 0   | 0 | 0 | 0 | 0 | 0                | 0                | 1                |  |
| Fader front left  | FFL | 0   | 0 | 0 | 0 | 0 | 0                | 1                | 0                |  |
| Fader rear right  | FRR | 0   | 0 | 0 | 0 | 0 | 0                | 1                | 1                |  |
| Fader rear left   | FRL | 0   | 0 | 0 | 0 | 0 | 1                | 0                | 0                |  |
| Bass              | BA  | 0   | 0 | 0 | 0 | 0 | 1                | 0                | 1                |  |
| Treble            | TR  | 0   | 0 | 0 | 0 | 0 | 1                | 1                | 0                |  |
| Switch            | S   | 0   | 0 | 0 | 0 | 0 | 1                | 1                | 1                |  |

**Note**

1. Significant subaddress.

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**Table 2** Definition of third byte after MAD and SAD

| FUNCTION          | BIT | MSB                 |                     |                     |                     |                     |                     |                     |                     | LSB |  |
|-------------------|-----|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|-----|--|
|                   |     | 7                   | 6                   | 5                   | 4                   | 3                   | 2                   | 1                   | 0                   |     |  |
| Volume/loudness   | V   | ZCM <sup>(1)</sup>  | LOFF <sup>(2)</sup> | V5 <sup>(3)</sup>   | V4 <sup>(3)</sup>   | V3 <sup>(3)</sup>   | V2 <sup>(3)</sup>   | V1 <sup>(3)</sup>   | V0 <sup>(3)</sup>   |     |  |
| Fader front right | FFR | 0                   | 0                   | FFR5 <sup>(5)</sup> | FFR4 <sup>(5)</sup> | FFR3 <sup>(5)</sup> | FFR2 <sup>(5)</sup> | FFR1 <sup>(5)</sup> | FFR0 <sup>(5)</sup> |     |  |
| Fader front left  | FFL | 0                   | 0                   | FFL5 <sup>(6)</sup> | FFL4 <sup>(6)</sup> | FFL3 <sup>(6)</sup> | FFL2 <sup>(6)</sup> | FFL1 <sup>(6)</sup> | FFL0 <sup>(6)</sup> |     |  |
| Fader rear right  | FRR | 0                   | 0                   | FRR5 <sup>(7)</sup> | FRR4 <sup>(7)</sup> | FRR3 <sup>(7)</sup> | FRR2 <sup>(7)</sup> | FRR1 <sup>(7)</sup> | FRR0 <sup>(7)</sup> |     |  |
| Fader rear left   | FRL | 0                   | 0                   | FRL5 <sup>(8)</sup> | FRL4 <sup>(8)</sup> | FRL3 <sup>(8)</sup> | FRL2 <sup>(8)</sup> | FRL1 <sup>(8)</sup> | FRL0 <sup>(8)</sup> |     |  |
| Bass              | BA  | 0                   | 0                   | 0                   | BA4 <sup>(9)</sup>  | BA3 <sup>(9)</sup>  | BA2 <sup>(9)</sup>  | BA1 <sup>(9)</sup>  | BA0 <sup>(9)</sup>  |     |  |
| Treble            | TR  | 0                   | 0                   | 0                   | TR4 <sup>(10)</sup> | TR3 <sup>(10)</sup> | TR2 <sup>(10)</sup> | TR1 <sup>(10)</sup> | TR0 <sup>(10)</sup> |     |  |
| Switch            | S   | GMU <sup>(11)</sup> | 0                   | 0                   | 0                   | 0                   | SC2 <sup>(12)</sup> | SC1 <sup>(12)</sup> | SC0 <sup>(12)</sup> |     |  |

**Notes**

1. Zero crossing mode.
2. Switch loudness on/off.
3. Volume control.
4. Don't care bits (logic 1 during testing).
5. Fader control front right.
6. Fader control front left.
7. Fader control rear right.
8. Fader control rear left.
9. Bass control.
10. Treble control.
11. Mute control for all outputs except OVL and OVR (general mute).
12. Source selector control.

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**Table 3** Volume I setting

| $G_v$<br>(dB)                                                                                                                    | DATA |    |    |    |    |    |
|----------------------------------------------------------------------------------------------------------------------------------|------|----|----|----|----|----|
|                                                                                                                                  | V5   | V4 | V3 | V2 | V1 | V0 |
| <b>Loudness on: the increment of the loudness characteristics is linear at every volume step in the range from +20 to -11 dB</b> |      |    |    |    |    |    |
| +20                                                                                                                              | 1    | 1  | 1  | 1  | 1  | 1  |
| +19                                                                                                                              | 1    | 1  | 1  | 1  | 1  | 0  |
| +18                                                                                                                              | 1    | 1  | 1  | 1  | 0  | 1  |
| +17                                                                                                                              | 1    | 1  | 1  | 1  | 0  | 0  |
| +16                                                                                                                              | 1    | 1  | 1  | 0  | 1  | 1  |
| +15                                                                                                                              | 1    | 1  | 1  | 0  | 1  | 0  |
| +14                                                                                                                              | 1    | 1  | 1  | 0  | 0  | 1  |
| +13                                                                                                                              | 1    | 1  | 1  | 0  | 0  | 0  |
| +12                                                                                                                              | 1    | 1  | 0  | 1  | 1  | 1  |
| +11                                                                                                                              | 1    | 1  | 0  | 1  | 1  | 0  |
| +10                                                                                                                              | 1    | 1  | 0  | 1  | 0  | 1  |
| +9                                                                                                                               | 1    | 1  | 0  | 1  | 0  | 0  |
| +8                                                                                                                               | 1    | 1  | 0  | 0  | 1  | 1  |
| +7                                                                                                                               | 1    | 1  | 0  | 0  | 1  | 0  |
| +6                                                                                                                               | 1    | 1  | 0  | 0  | 0  | 1  |
| +5                                                                                                                               | 1    | 1  | 0  | 0  | 0  | 0  |
| +4                                                                                                                               | 1    | 0  | 1  | 1  | 1  | 1  |
| +3                                                                                                                               | 1    | 0  | 1  | 1  | 1  | 0  |
| +2                                                                                                                               | 1    | 0  | 1  | 1  | 0  | 1  |
| +1                                                                                                                               | 1    | 0  | 1  | 1  | 0  | 0  |
| 0                                                                                                                                | 1    | 0  | 1  | 0  | 1  | 1  |
| -1                                                                                                                               | 1    | 0  | 1  | 0  | 1  | 0  |
| -2                                                                                                                               | 1    | 0  | 1  | 0  | 0  | 1  |
| -3                                                                                                                               | 1    | 0  | 1  | 0  | 0  | 0  |
| -4                                                                                                                               | 1    | 0  | 0  | 1  | 1  | 1  |
| -5                                                                                                                               | 1    | 0  | 0  | 1  | 1  | 0  |
| -6                                                                                                                               | 1    | 0  | 0  | 1  | 0  | 1  |
| -7                                                                                                                               | 1    | 0  | 0  | 1  | 0  | 0  |
| -8                                                                                                                               | 1    | 0  | 0  | 0  | 1  | 1  |
| -9                                                                                                                               | 1    | 0  | 0  | 0  | 1  | 0  |
| -10                                                                                                                              | 1    | 0  | 0  | 0  | 0  | 1  |
| -11                                                                                                                              | 1    | 0  | 0  | 0  | 0  | 0  |

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| $G_v$<br>(dB)                                                        | DATA |    |    |    |    |    |
|----------------------------------------------------------------------|------|----|----|----|----|----|
|                                                                      | V5   | V4 | V3 | V2 | V1 | V0 |
| Loudness characteristic is constant in a range from –11 dB to –31 dB |      |    |    |    |    |    |
| –12                                                                  | 0    | 1  | 1  | 1  | 1  | 1  |
| –13                                                                  | 0    | 1  | 1  | 1  | 1  | 0  |
| –14                                                                  | 0    | 1  | 1  | 1  | 0  | 1  |
| –15                                                                  | 0    | 1  | 1  | 1  | 0  | 0  |
| –16                                                                  | 0    | 1  | 1  | 0  | 1  | 1  |
| –17                                                                  | 0    | 1  | 1  | 0  | 1  | 0  |
| –18                                                                  | 0    | 1  | 1  | 0  | 0  | 1  |
| –19                                                                  | 0    | 1  | 1  | 0  | 0  | 0  |
| –20                                                                  | 0    | 1  | 0  | 1  | 1  | 1  |
| –21                                                                  | 0    | 1  | 0  | 1  | 1  | 0  |
| –22                                                                  | 0    | 1  | 0  | 1  | 0  | 1  |
| –23                                                                  | 0    | 1  | 0  | 1  | 0  | 0  |
| –24                                                                  | 0    | 1  | 0  | 0  | 1  | 1  |
| –25                                                                  | 0    | 1  | 0  | 0  | 1  | 0  |
| –26                                                                  | 0    | 1  | 0  | 0  | 0  | 1  |
| –27                                                                  | 0    | 1  | 0  | 0  | 0  | 0  |
| –28                                                                  | 0    | 0  | 1  | 1  | 1  | 1  |
| –29                                                                  | 0    | 0  | 1  | 1  | 1  | 0  |
| –30                                                                  | 0    | 0  | 1  | 1  | 0  | 1  |
| –31                                                                  | 0    | 0  | 1  | 1  | 0  | 0  |
| Repetition of steps in a range from –28 dB to –31 dB                 |      |    |    |    |    |    |
| –28                                                                  | 0    | 0  | 1  | 0  | 1  | 1  |
| –29                                                                  | 0    | 0  | 1  | 0  | 1  | 0  |
| –30                                                                  | 0    | 0  | 1  | 0  | 0  | 1  |
| –31                                                                  | 0    | 0  | 1  | 0  | 0  | 0  |
| –28                                                                  | 0    | 0  | 0  | 1  | 1  | 1  |
| –29                                                                  | 0    | 0  | 0  | 1  | 1  | 0  |
| –30                                                                  | 0    | 0  | 0  | 1  | 0  | 1  |
| –31                                                                  | 0    | 0  | 0  | 1  | 0  | 0  |
| –28                                                                  | 0    | 0  | 0  | 0  | 1  | 1  |
| –29                                                                  | 0    | 0  | 0  | 0  | 1  | 0  |
| –30                                                                  | 0    | 0  | 0  | 0  | 0  | 1  |
| –31                                                                  | 0    | 0  | 0  | 0  | 0  | 0  |

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**Table 4** Volume II setting (fader and balance)

| $G_v$<br>(dB) | DATA |      |      |      |      |      |
|---------------|------|------|------|------|------|------|
|               | FRR5 | FRR4 | FRR3 | FRR2 | FRR1 | FRR0 |
|               | FRL5 | FRL4 | FRL3 | FRL2 | FRL1 | FRL0 |
|               | FFL5 | FFL4 | FFL3 | FFL2 | FFL1 | FFL0 |
|               | FFR5 | FFR4 | FFR3 | FFR2 | FFR1 | FFR0 |
| 0             | 1    | 1    | 1    | 1    | 1    | 1    |
| -1            | 1    | 1    | 1    | 1    | 1    | 0    |
| -2            | 1    | 1    | 1    | 1    | 0    | 1    |
| -3            | 1    | 1    | 1    | 1    | 0    | 0    |
| -4            | 1    | 1    | 1    | 0    | 1    | 1    |
| -5            | 1    | 1    | 1    | 0    | 1    | 0    |
| -6            | 1    | 1    | 1    | 0    | 0    | 1    |
| -7            | 1    | 1    | 1    | 0    | 0    | 0    |
| -8            | 1    | 1    | 0    | 1    | 1    | 1    |
| -9            | 1    | 1    | 0    | 1    | 1    | 0    |
| -10           | 1    | 1    | 0    | 1    | 0    | 1    |
| -11           | 1    | 1    | 0    | 1    | 0    | 0    |
| -12           | 1    | 1    | 0    | 0    | 1    | 1    |
| -13           | 1    | 1    | 0    | 0    | 1    | 0    |
| -14           | 1    | 1    | 0    | 0    | 0    | 1    |
| -15           | 1    | 1    | 0    | 0    | 0    | 0    |
| -16           | 1    | 0    | 1    | 1    | 1    | 1    |
| -17           | 1    | 0    | 1    | 1    | 1    | 0    |
| -18           | 1    | 0    | 1    | 1    | 0    | 1    |
| -19           | 1    | 0    | 1    | 1    | 0    | 0    |
| -20           | 1    | 0    | 1    | 0    | 1    | 1    |
| -21           | 1    | 0    | 1    | 0    | 1    | 0    |
| -22           | 1    | 0    | 1    | 0    | 0    | 1    |
| -23           | 1    | 0    | 1    | 0    | 0    | 0    |
| -24           | 1    | 0    | 0    | 1    | 1    | 1    |
| -25           | 1    | 0    | 0    | 1    | 1    | 0    |
| -26           | 1    | 0    | 0    | 1    | 0    | 1    |
| -27           | 1    | 0    | 0    | 1    | 0    | 0    |
| -28           | 1    | 0    | 0    | 0    | 1    | 1    |
| -29           | 1    | 0    | 0    | 0    | 1    | 0    |
| -30           | 1    | 0    | 0    | 0    | 0    | 1    |
| -31           | 1    | 0    | 0    | 0    | 0    | 0    |
| -32           | 0    | 1    | 1    | 1    | 1    | 1    |
| -33           | 0    | 1    | 1    | 1    | 1    | 0    |
| -34           | 0    | 1    | 1    | 1    | 0    | 1    |

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| $G_v$<br>(dB) | DATA |      |      |      |      |      |
|---------------|------|------|------|------|------|------|
|               | FRR5 | FRR4 | FRR3 | FRR2 | FRR1 | FRR0 |
|               | FRL5 | FRL4 | FRL3 | FRL2 | FRL1 | FRL0 |
|               | FFL5 | FFL4 | FFL3 | FFL2 | FFL1 | FFL0 |
|               | FFR5 | FFR4 | FFR3 | FFR2 | FFR1 | FFR0 |
| -35           | 0    | 1    | 1    | 1    | 0    | 0    |
| -36           | 0    | 1    | 1    | 0    | 1    | 1    |
| -37           | 0    | 1    | 1    | 0    | 1    | 0    |
| -38           | 0    | 1    | 1    | 0    | 0    | 1    |
| -39           | 0    | 1    | 1    | 0    | 0    | 0    |
| -40           | 0    | 1    | 0    | 1    | 1    | 1    |
| -41           | 0    | 1    | 0    | 1    | 1    | 0    |
| -42           | 0    | 1    | 0    | 1    | 0    | 1    |
| -43           | 0    | 1    | 0    | 1    | 0    | 0    |
| -44           | 0    | 1    | 0    | 0    | 1    | 1    |
| -45           | 0    | 1    | 0    | 0    | 1    | 0    |
| -46           | 0    | 1    | 0    | 0    | 0    | 1    |
| -47           | 0    | 1    | 0    | 0    | 0    | 0    |
| -48           | 0    | 0    | 1    | 1    | 1    | 1    |
| -49           | 0    | 0    | 1    | 1    | 1    | 0    |
| -50           | 0    | 0    | 1    | 1    | 0    | 1    |
| -51           | 0    | 0    | 1    | 1    | 0    | 0    |
| -52           | 0    | 0    | 1    | 0    | 1    | 1    |
| -53           | 0    | 0    | 1    | 0    | 1    | 0    |
| -54           | 0    | 0    | 1    | 0    | 0    | 1    |
| -55           | 0    | 0    | 1    | 0    | 0    | 0    |
| mute          | 0    | 0    | 0    | 1    | 1    | 1    |
| mute          | 0    | 0    | 0    | 1    | 1    | 0    |
| mute          | 0    | 0    | 0    | 1    | 0    | 1    |
| mute          | 0    | 0    | 0    | 1    | 0    | 0    |
| mute          | 0    | 0    | 0    | 0    | 1    | 1    |
| mute          | 0    | 0    | 0    | 0    | 1    | 0    |
| mute          | 0    | 0    | 0    | 0    | 0    | 1    |
| mute          | 0    | 0    | 0    | 0    | 0    | 0    |

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**Table 5** Bass setting

| <b>G<sub>bass</sub><br/>(dB)</b> | <b>DATA</b> |            |            |            |            |
|----------------------------------|-------------|------------|------------|------------|------------|
|                                  | <b>BA4</b>  | <b>BA3</b> | <b>BA2</b> | <b>BA1</b> | <b>BA0</b> |
| +18.0                            | 1           | 1          | 1          | 1          | 1          |
| +16.2                            | 1           | 1          | 1          | 1          | 0          |
| +18.0                            | 1           | 1          | 1          | 0          | 1          |
| +16.2                            | 1           | 1          | 1          | 0          | 0          |
| +18.0                            | 1           | 1          | 0          | 1          | 1          |
| +16.2                            | 1           | 1          | 0          | 1          | 0          |
| +14.4                            | 1           | 1          | 0          | 0          | 1          |
| +12.6                            | 1           | 1          | 0          | 0          | 0          |
| +10.8                            | 1           | 0          | 1          | 1          | 1          |
| +9.0                             | 1           | 0          | 1          | 1          | 0          |
| +7.2                             | 1           | 0          | 1          | 0          | 1          |
| +5.4                             | 1           | 0          | 1          | 0          | 0          |
| +3.6                             | 1           | 0          | 0          | 1          | 1          |
| +1.8                             | 1           | 0          | 0          | 1          | 0          |
| 0 <sup>(1)</sup>                 | 1           | 0          | 0          | 0          | 1          |
| 0 <sup>(2)</sup>                 | 1           | 0          | 0          | 0          | 0          |
| -1.8                             | 0           | 1          | 1          | 1          | 1          |
| -3.6                             | 0           | 1          | 1          | 1          | 0          |
| -5.4                             | 0           | 1          | 1          | 0          | 1          |
| -7.2                             | 0           | 1          | 1          | 0          | 0          |
| -9.0                             | 0           | 1          | 0          | 1          | 1          |
| -10.8                            | 0           | 1          | 0          | 1          | 0          |
| -12.6                            | 0           | 1          | 0          | 0          | 1          |
| -14.4                            | 0           | 1          | 0          | 0          | 0          |
| -16.2                            | 0           | 0          | 1          | 1          | 1          |
| -18.0                            | 0           | 0          | 1          | 1          | 0          |
| -16.2                            | 0           | 0          | 1          | 0          | 1          |
| -18.0                            | 0           | 0          | 1          | 0          | 0          |
| note 3                           | 0           | 0          | 0          | 1          | 1          |
| note 3                           | 0           | 0          | 0          | 1          | 0          |
| note 3                           | 0           | 0          | 0          | 0          | 1          |
| notes 3 and 4                    | 0           | 0          | 0          | 0          | 0          |

**Notes**

1. Recommended data word for step 0 dB.
2. Result of 1.8 dB boost and 1.8 dB attenuation.
3. The last four bass control data words mute the bass response.
4. The last bass control and treble control data words (00000) enable the external equalizer connection.

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**Table 6** Treble setting

| <b>G<sub>treble</sub></b><br><b>(dB)</b> | <b>DATA</b> |            |            |            |            |
|------------------------------------------|-------------|------------|------------|------------|------------|
|                                          | <b>TR4</b>  | <b>TR3</b> | <b>TR2</b> | <b>TR1</b> | <b>TR0</b> |
| +12.0                                    | 1           | 1          | 1          | 1          | 1          |
| +10.5                                    | 1           | 1          | 1          | 1          | 0          |
| +12.0                                    | 1           | 1          | 1          | 0          | 1          |
| +10.5                                    | 1           | 1          | 1          | 0          | 0          |
| +12.0                                    | 1           | 1          | 0          | 1          | 1          |
| +10.5                                    | 1           | 1          | 0          | 1          | 0          |
| +12.0                                    | 1           | 1          | 0          | 0          | 1          |
| +10.5                                    | 1           | 1          | 0          | 0          | 0          |
| +9.0                                     | 1           | 0          | 1          | 1          | 1          |
| +7.5                                     | 1           | 0          | 1          | 1          | 0          |
| +6.0                                     | 1           | 0          | 1          | 0          | 1          |
| +4.5                                     | 1           | 0          | 1          | 0          | 0          |
| +3.0                                     | 1           | 0          | 0          | 1          | 1          |
| +1.5                                     | 1           | 0          | 0          | 1          | 0          |
| 0 <sup>(1)</sup>                         | 1           | 0          | 0          | 0          | 1          |
| 0 <sup>(2)</sup>                         | 1           | 0          | 0          | 0          | 0          |
| -1.5                                     | 0           | 1          | 1          | 1          | 1          |
| -3.0                                     | 0           | 1          | 1          | 1          | 0          |
| -4.5                                     | 0           | 1          | 1          | 0          | 1          |
| -6.0                                     | 0           | 1          | 1          | 0          | 0          |
| -7.5                                     | 0           | 1          | 0          | 1          | 1          |
| -9.0                                     | 0           | 1          | 0          | 1          | 0          |
| -10.5                                    | 0           | 1          | 0          | 0          | 1          |
| -12.0                                    | 0           | 1          | 0          | 0          | 0          |
| note 3                                   | 0           | 0          | 1          | 1          | 1          |
| note 3                                   | 0           | 0          | 1          | 1          | 0          |
| note 3                                   | 0           | 0          | 1          | 0          | 1          |
| note 3                                   | 0           | 0          | 1          | 0          | 0          |
| note 3                                   | 0           | 0          | 0          | 1          | 1          |
| note 3                                   | 0           | 0          | 0          | 1          | 0          |
| note 3                                   | 0           | 0          | 0          | 0          | 1          |
| notes 3 and 4                            | 0           | 0          | 0          | 0          | 0          |

**Notes**

1. Recommended data word for step 0 dB.
2. Result of 1.5 dB boost and 1.5 dB attenuation.
3. The last eight treble control data words select treble output.
4. The last treble control and bass control data words (00000) enable the external equalizer connection.

## Sound fader control circuit

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**Table 7** Loudness setting

| CHARACTERISTIC | DATA LOFF |
|----------------|-----------|
| With loudness  | 0         |
| Linear         | 1         |

**Table 8** Selected input

| FUNCTION                             | DATA |     |     |
|--------------------------------------|------|-----|-----|
|                                      | SC2  | SC1 | SC0 |
| Stereo inputs IAL and IAR            | 1    | 1   | 1   |
| Stereo inputs IBL and IBR            | 1    | 1   | 0   |
| Stereo inputs ICL and ICR            | 1    | 0   | 1   |
| Stereo inputs IDL and IDR            | 1    | 0   | 0   |
| (Stereo inputs) IAL and IAR          | 0    | 1   | 1   |
| Differential inputs IAL, IAR and COM | 0    | 1   | 0   |
| No input (input mute)                | 0    | 0   | 1   |
| Mono input COM                       | 0    | 0   | 0   |

**Table 9** Mute mode

| FUNCTION                                      | DATA |     |
|-----------------------------------------------|------|-----|
|                                               | GMU  | ZCM |
| Direct mute off                               | 0    | 0   |
| Mute off delayed until the next zero crossing | 0    | 1   |
| Direct mute                                   | 1    | 0   |
| Mute delayed until the next zero crossing     | 1    | 1   |

Sound fader control circuit

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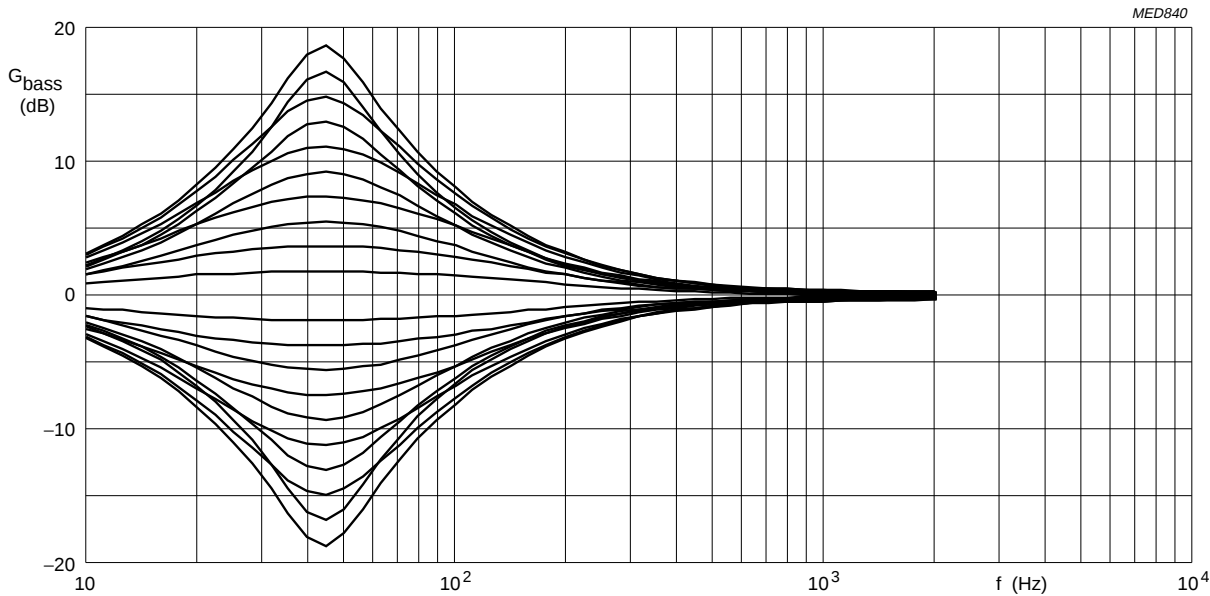


Fig.3 Bass control.

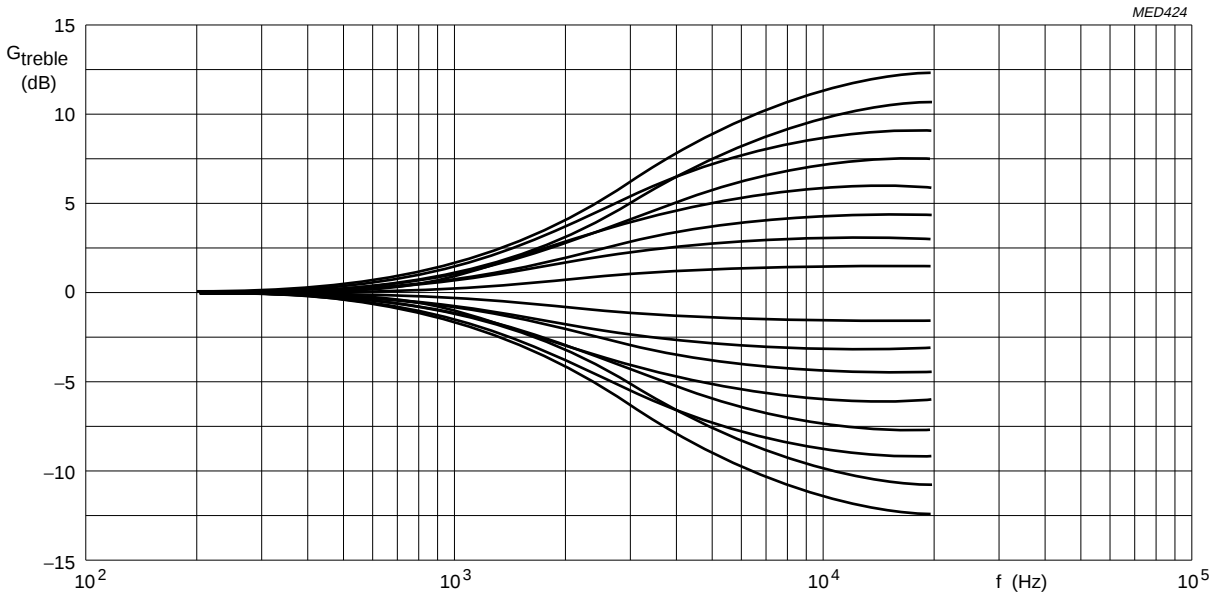


Fig.4 Treble control.

## Sound fader control circuit

TEA6323T

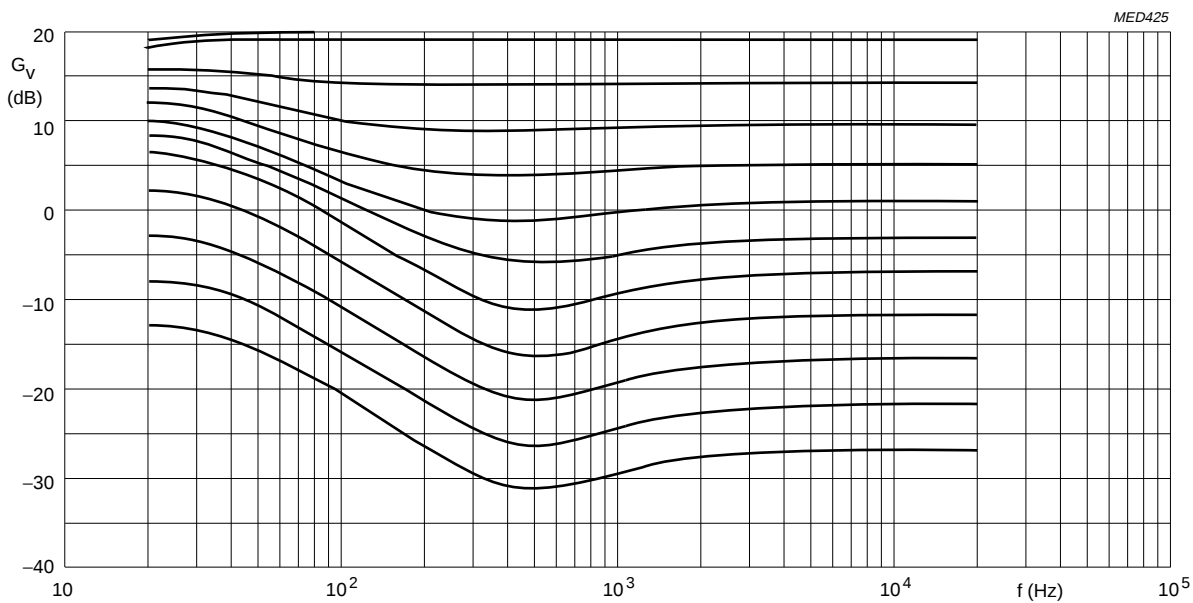


Fig.5 Volume control with loudness (including low roll-off frequency).

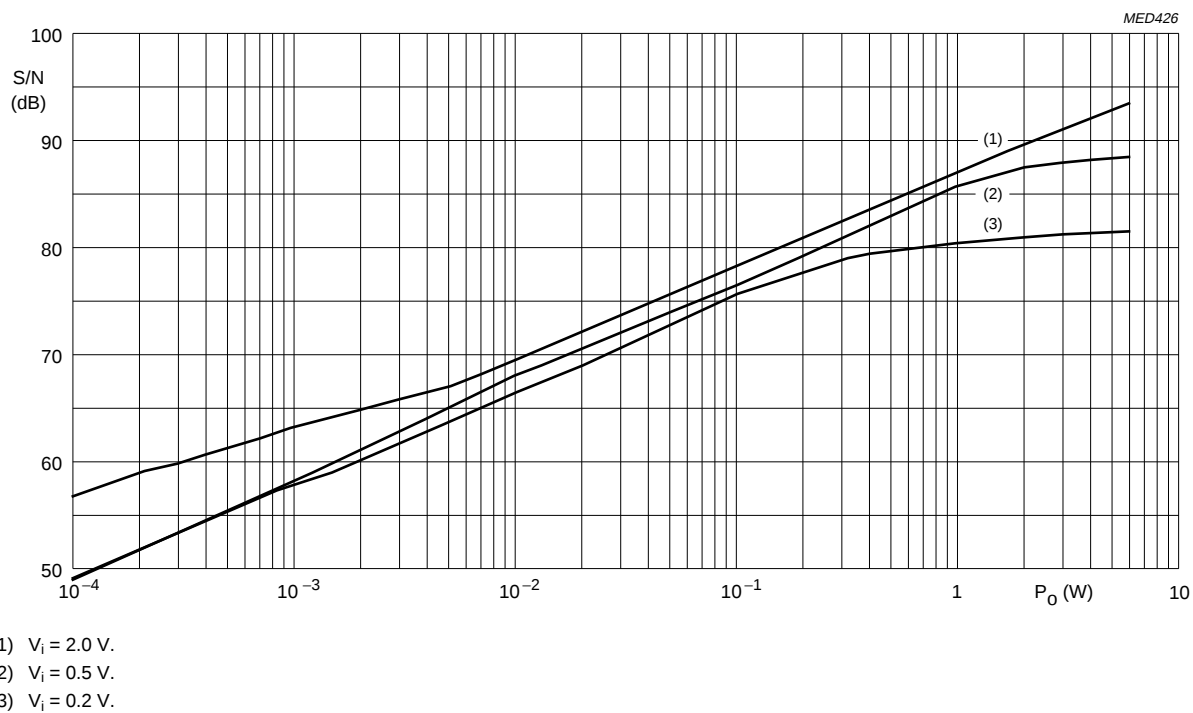
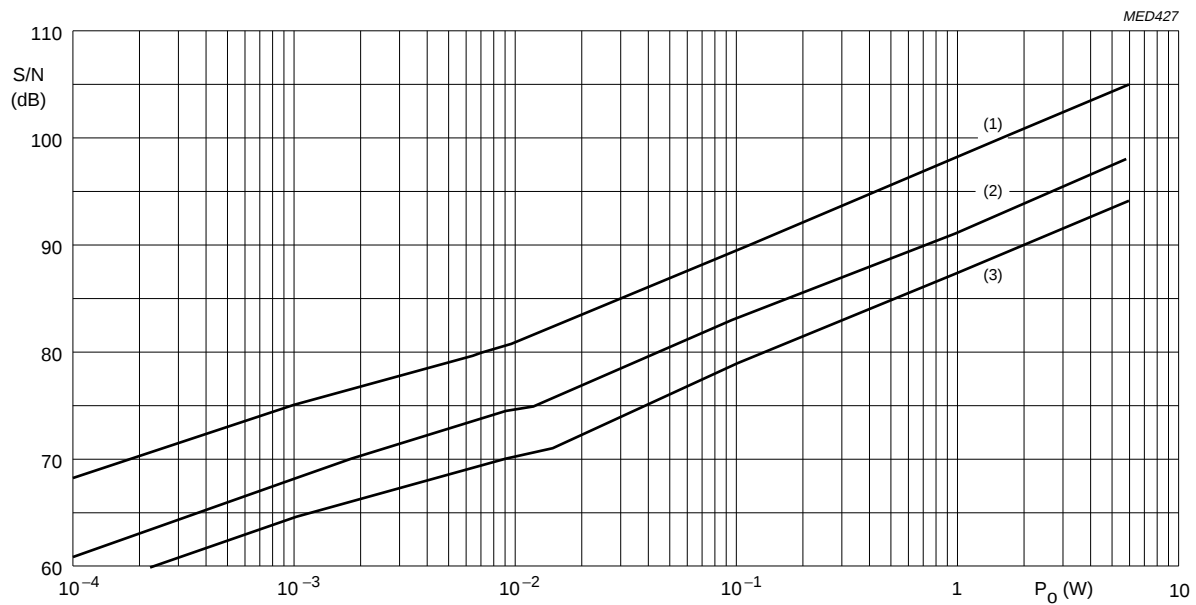


Fig.6 Signal-to-noise ratio; noise weighted: CCIR468-2, quasi peak.

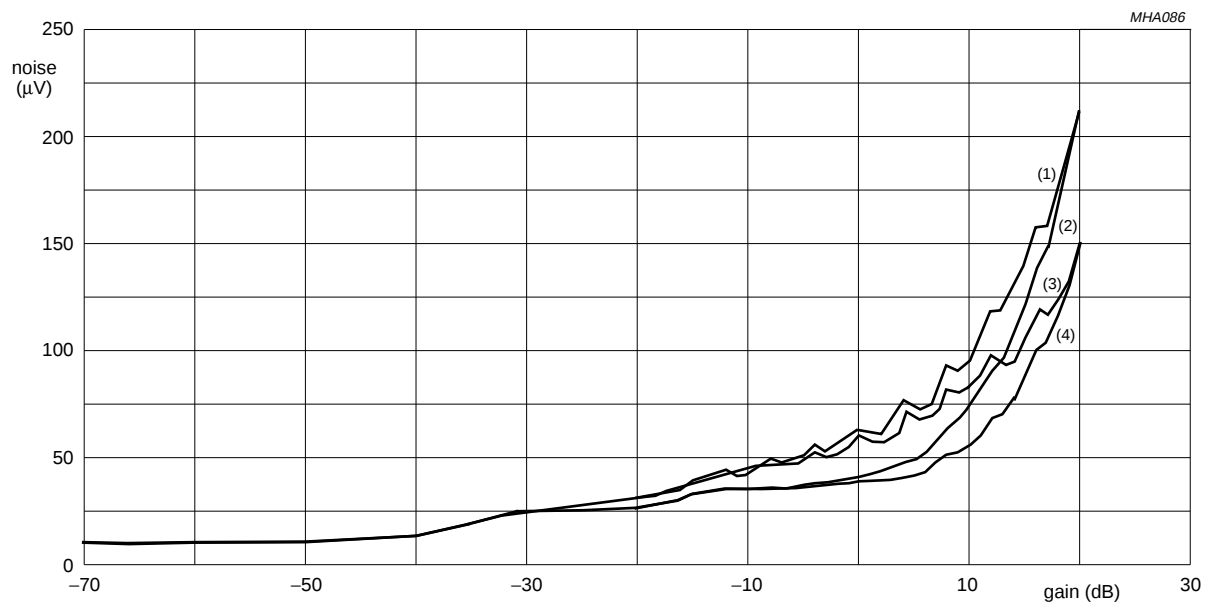
## Sound fader control circuit

TEA6323T



- (1) Unweighted RMS.  
 (2) CCIR468-2 RMS.  
 (3) CCIR468-2 quasi peak.

Fig.7 Signal-to-noise ratio;  $V_i = 2\text{ V}$ ;  $P_{\max} = 6\text{ W}$ .



- (1) Symmetrical input; loudness on. (3) Stereo/mono inputs; loudness on.  
 (2) Symmetrical input; loudness off. (4) Stereo/mono inputs; loudness off.

Fig.8 Noise output voltage; CCIR468-2, quasi peak

## Sound fader control circuit

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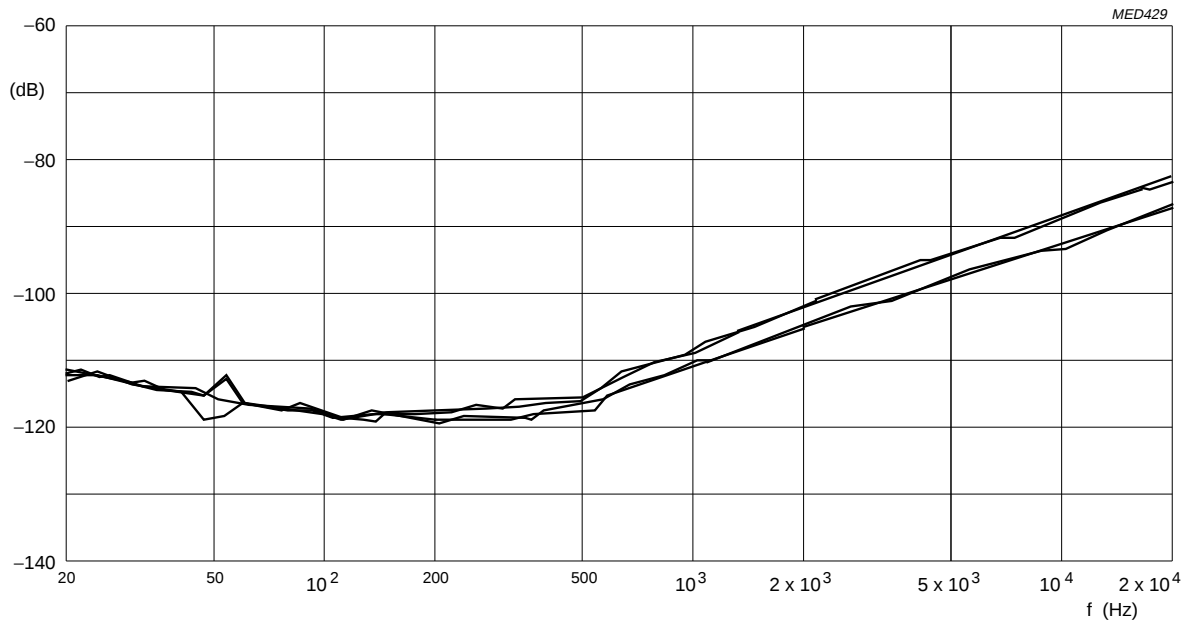


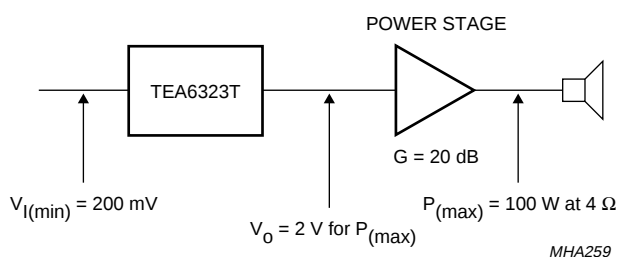
Fig.9 Muting.

## Sound fader control circuit

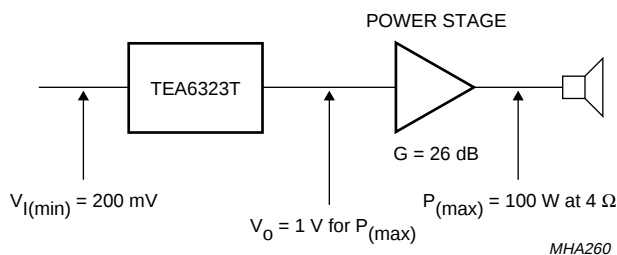
## TEA6323T

If the 20 dB gain is not required for the maximum volume position, it will be an advantage to use the maximum boost gain and then increased attenuation in the last section, Volume II.

Therefore the loudness will be at the correct place and a lower noise and offset voltage will be achieved.



a.



b.

- a. Gain volume I = 20 dB ( $G_{V(\max)}$ ); gain volume II = 0 dB; fader and balance range = 55 dB.
- b. Gain volume I = 20 dB ( $G_{V(\max)}$ ); gain volume II = -6 dB global setting; fader and balance range now 49 dB, previously 55 dB.

Fig.10 Level diagram.

Sound fader control circuit

TEA6323T

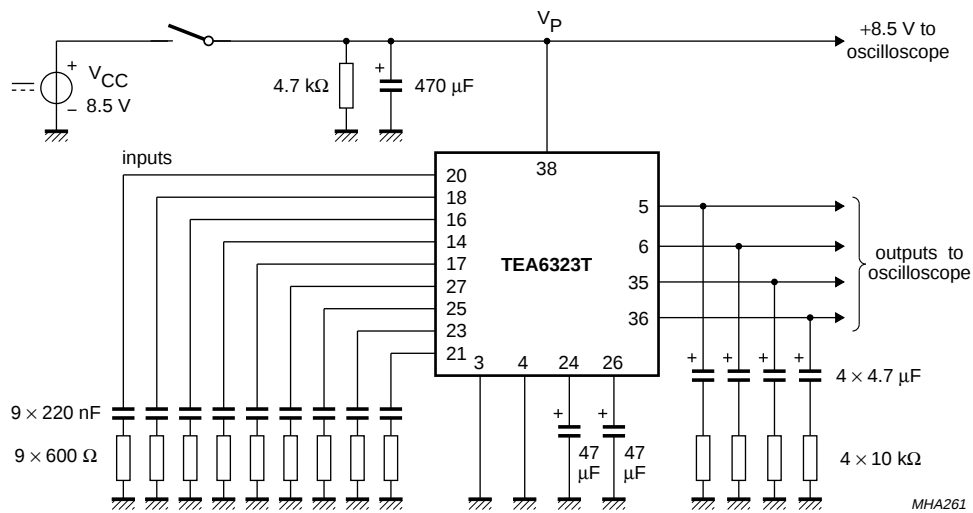


Fig.11 Turn-on/off power supply circuit diagram.

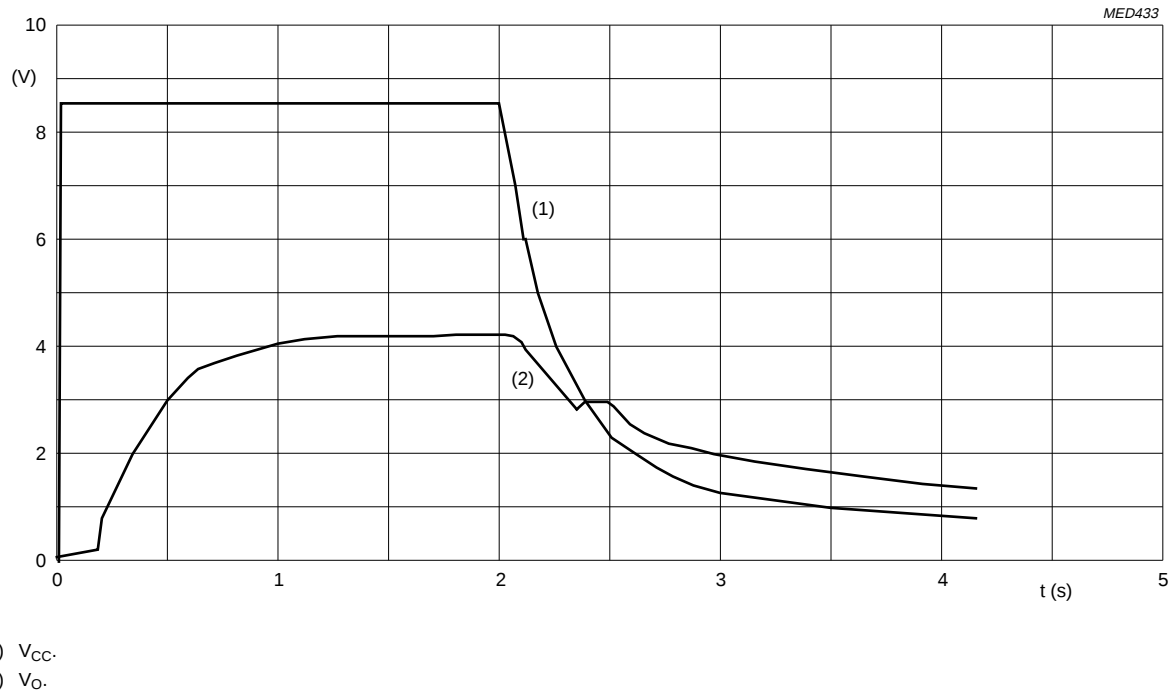


Fig.12 Turn-on/off behaviour.

## Sound fader control circuit

## TEA6323T

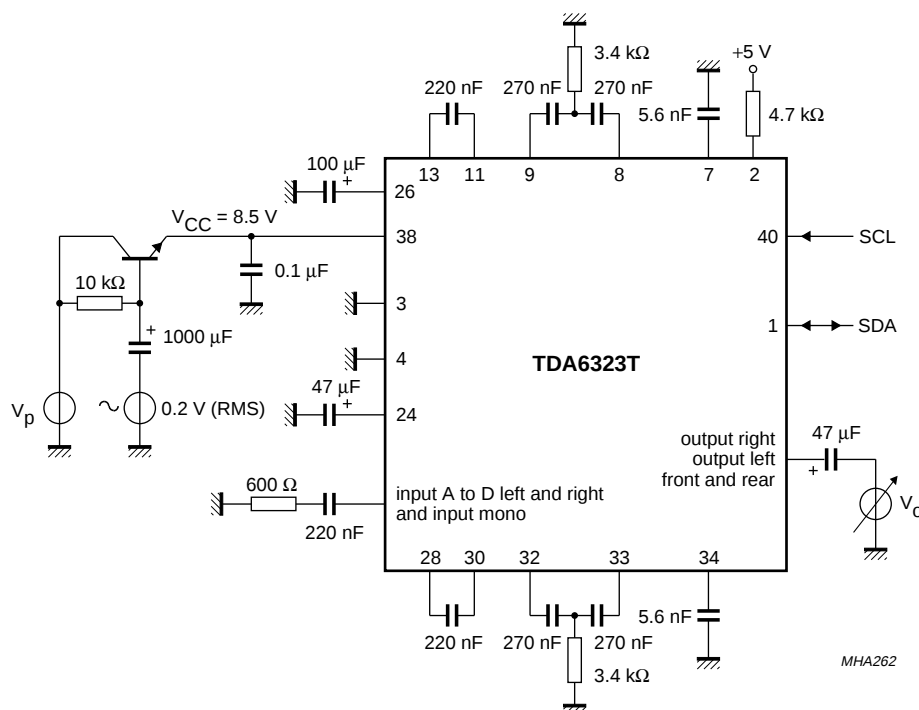
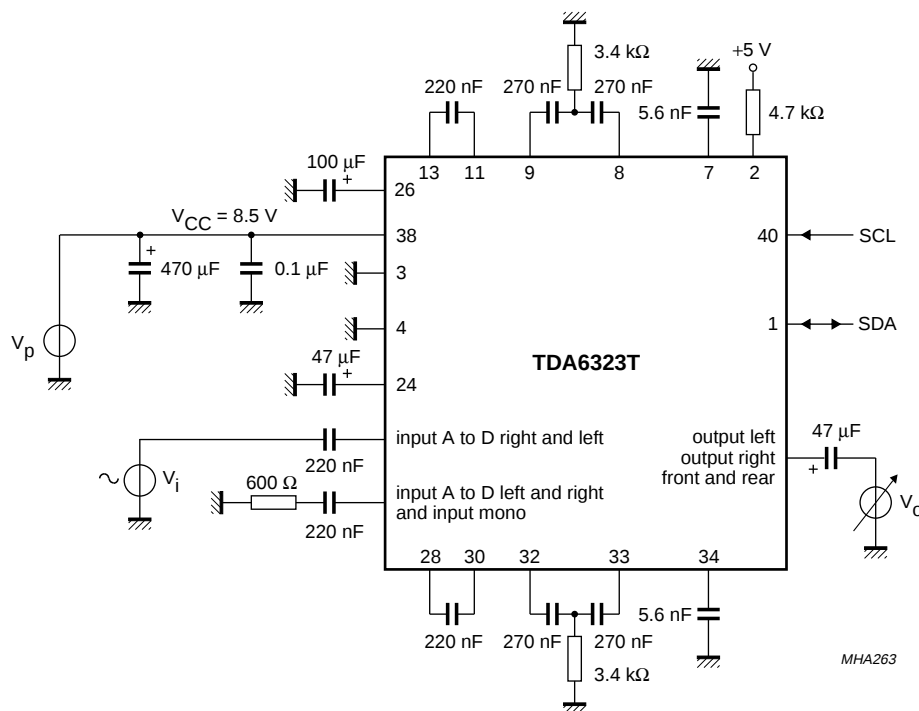


Fig.13 Test circuit for power supply ripple rejection (RR).

Fig.14 Test circuit for channel separation ( $\alpha_{cs}$ ).

## Sound fader control circuit

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**Loudness filter calculation example**

Figure 15 shows the basic loudness circuit with an external low-pass filter application. R1 allows an attenuation range of 21 dB while the boost is determined by the gain stage V<sub>2</sub>. Both result in a loudness control range of +20 to -12 dB.

Defining f<sub>ref</sub> as the frequency where the level does not change while switching loudness on/off. The external resistor R3 for f<sub>ref</sub> → ∞ can be calculated as

$$R3 = R1 \frac{10^{\frac{G_v}{20}}}{1 - 10^{\frac{G_v}{20}}}. \text{ With } G_v = -21 \text{ dB and } R1 = 33 \text{ k}\Omega,$$

R3 = 3.2 kΩ is generated.

For the low-pass filter characteristic the value of the external capacitor C1 can be determined by setting a specific boost for a defined frequency and referring the gain to G<sub>v</sub> at f<sub>ref</sub> as indicated above.

$$\left| \frac{1}{j(\omega C1)} \right| = \frac{(R1 + R3) \times 10^{\frac{G_v}{20}} - R3}{1 - 10^{\frac{G_v}{20}}}$$

For example: 3 dB boost at f = 1 kHz

G<sub>v</sub> = G<sub>v(ref)</sub> + 3 dB = -18 dB; f = 1 kHz and C1 = 100 nF.

If a loudness characteristic with additional high frequency boost is desired, an additional high-pass section has to be included in the external filter circuit as indicated in the block diagram. A filter configuration that provides AC coupling avoids offset voltage problems.

Figure 16 shows an example of the loudness circuit with bass and treble boost. The calculation of this network is numeric.

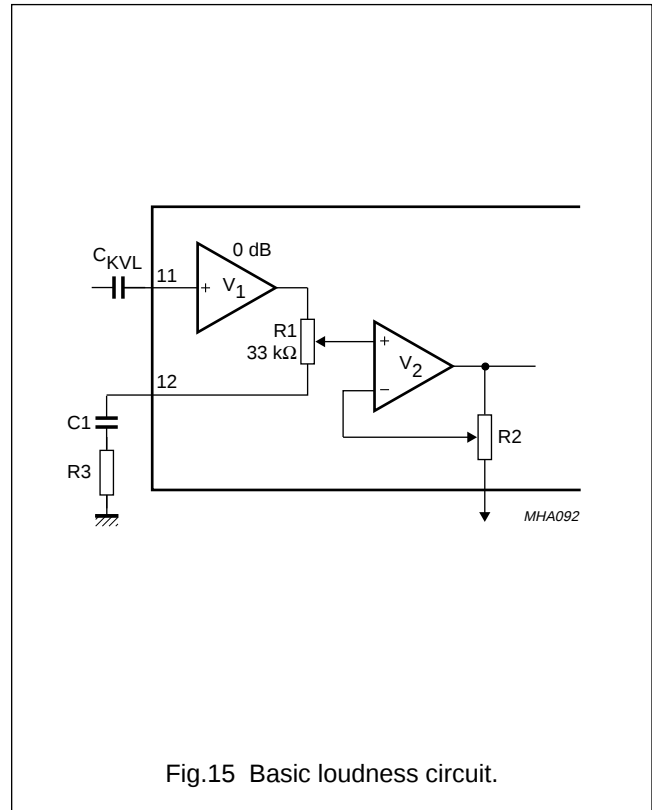


Fig.15 Basic loudness circuit.

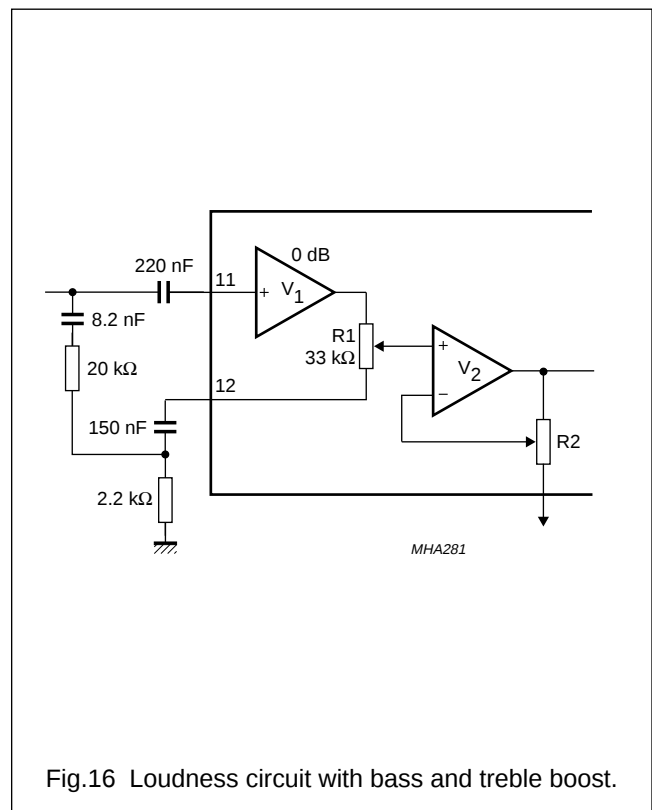


Fig.16 Loudness circuit with bass and treble boost.

## Sound fader control circuit

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## INTERNAL PIN CONFIGURATIONS

Values shown in Figs 17 to 29 are typical DC values;  
 $V_{CC} = 8.5 \text{ V}$ .

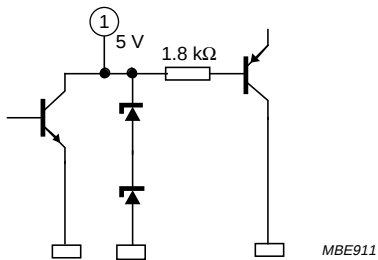
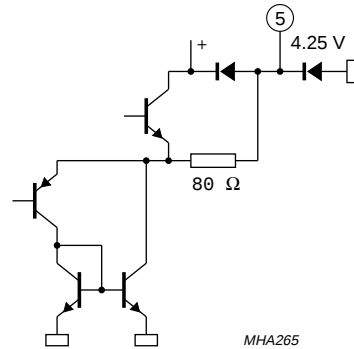
Fig.17 Pin 1: SDA (I<sup>2</sup>C-bus data).

Fig.18 Pins 5, 6, 10, 31, 35, 36: output signals.

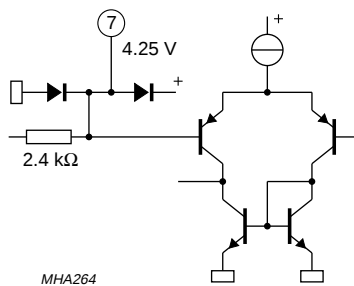


Fig.19 Pins 7 and 34: treble control capacitors.

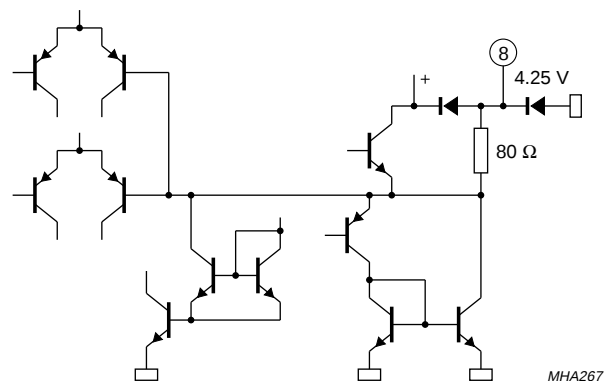


Fig.20 Pins 8 and 33: bass control capacitor outputs.

## Sound fader control circuit

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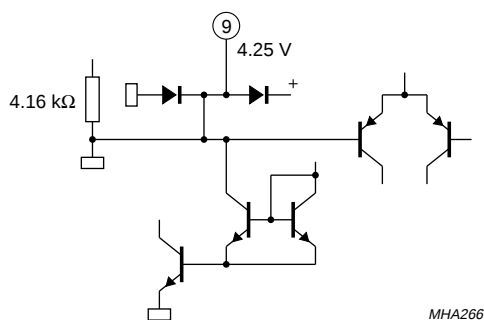


Fig.21 Pins 9 and 32: bass control capacitor inputs.

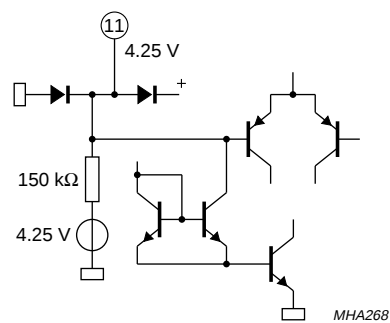


Fig.22 Pins 11 and 30: input volume 1, control part.

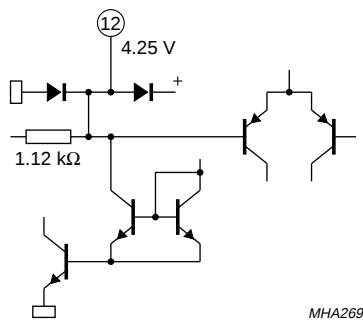


Fig.23 Pins 12 and 29: input loudness, control part.

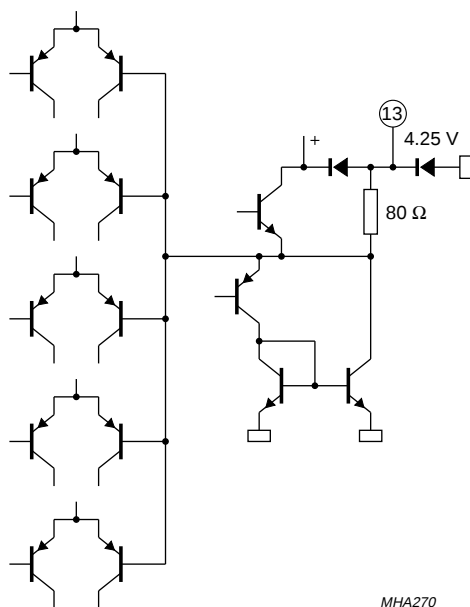


Fig.24 Pins 13 and 28: output source selector.

## Sound fader control circuit

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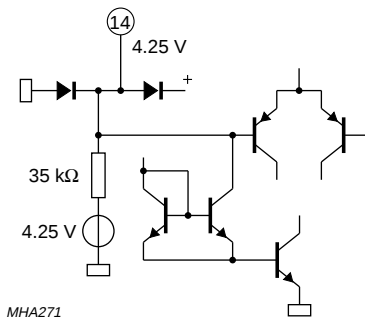


Fig.25 Pins 14, 16 to 18, 20, 21, 23, 25, 27: inputs.

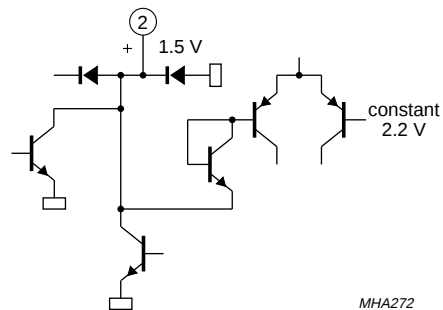


Fig.26 Pin 2: mute control.

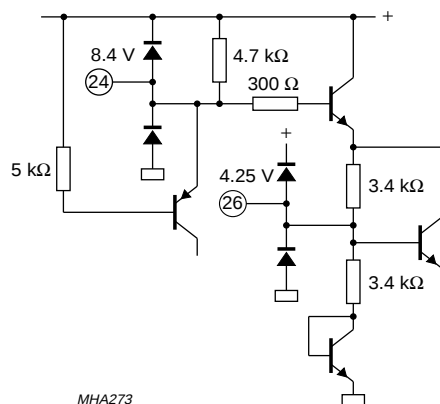


Fig.27 Pin 24: filtering for supply; pin 26: reference voltage.

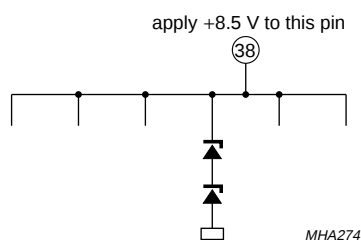


Fig.28 Pin 38: supply voltage.

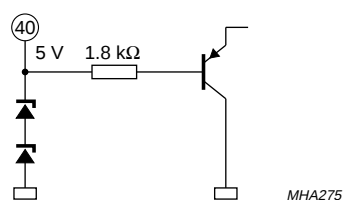


Fig.29 Pin 40: SCL (I²C-bus clock).

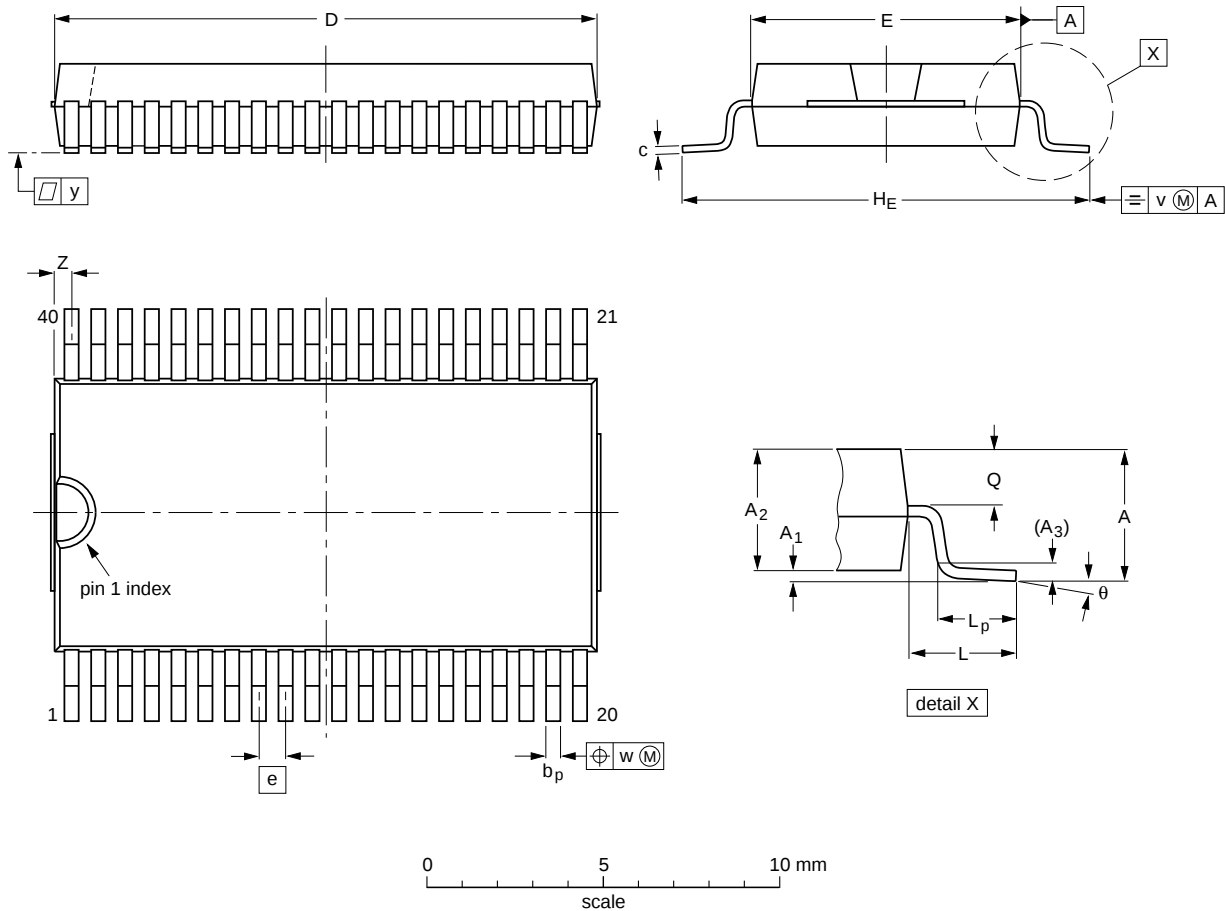
Sound fader control circuit

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PACKAGE OUTLINE

VSO40: plastic very small outline package; 40 leads

SOT158-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

| UNIT   | A<br>max. | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c                | D <sup>(1)</sup> | E <sup>(2)</sup> | e     | H <sub>E</sub> | L     | L <sub>p</sub> | Q              | v     | w     | y     | Z <sup>(1)</sup> | θ        |
|--------|-----------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|-------|----------------|-------|----------------|----------------|-------|-------|-------|------------------|----------|
| mm     | 2.70      | 0.3<br>0.1     | 2.45<br>2.25   | 0.25           | 0.42<br>0.30   | 0.22<br>0.14     | 15.6<br>15.2     | 7.6<br>7.5       | 0.762 | 12.3<br>11.8   | 2.25  | 1.7<br>1.5     | 1.15<br>1.05   | 0.2   | 0.1   | 0.1   | 0.6<br>0.3       | 7°<br>0° |
| inches | 0.11      | 0.012<br>0.004 | 0.096<br>0.089 | 0.010          | 0.017<br>0.012 | 0.0087<br>0.0055 | 0.61<br>0.60     | 0.30<br>0.29     | 0.03  | 0.48<br>0.46   | 0.089 | 0.067<br>0.059 | 0.045<br>0.041 | 0.008 | 0.004 | 0.004 | 0.024<br>0.012   |          |

- Notes
- 1. Plastic or metal protrusions of 0.4 mm maximum per side are not included.
  - 2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

| OUTLINE<br>VERSION | REFERENCES |       |      |  | EUROPEAN<br>PROJECTION | ISSUE DATE           |
|--------------------|------------|-------|------|--|------------------------|----------------------|
|                    | IEC        | JEDEC | EIAJ |  |                        |                      |
| SOT158-1           |            |       |      |  |                        | 92-11-17<br>95-01-24 |

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## Sound fader control circuit

## TEA6323T

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### SOLDERING

#### Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"IC Package Databook"* (order code 9398 652 90011).

#### Reflow soldering

Reflow soldering techniques are suitable for all VSO packages.

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt. Dwell times vary between 50 and 300 seconds depending on heating method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 minutes at 45 °C.

#### Wave soldering

Wave soldering techniques can be used for all VSO packages if the following conditions are observed:

- A double-wave (a turbulent wave with high upward pressure followed by a smooth laminar wave) soldering technique should be used.
- The longitudinal axis of the package footprint must be parallel to the solder flow.
- The package footprint must incorporate solder thieves at the downstream end.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder is 10 seconds, if cooled to less than 150 °C within 6 seconds. Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

#### Repairing soldered joints

Fix the component by first soldering two diagonally-opposite end leads. Use only a low voltage soldering iron (less than 24 V) applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C. When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.