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# DATA SHEET

# TEA6321
## Sound fader control circuit

Preliminary specification
Supersedes data of August 1993
File under Integrated Circuits, IC01

1995 Dec 19

Philips
Semiconductors

PHILIPS

## FEATURES

- Source selector for four stereo and one mono inputs
- Interface for noise reduction circuits
- Interface for external equalizer
- Volume, balance and fader control
- Special loudness characteristic automatically controlled in combination with volume setting
- Bass control with equalizer filters
- Treble control
- Mute control at audio signal zero crossing
- Fast mute control via I²C-bus
- Fast mute control via pin
- I²C-bus control for all functions
- Power supply with internal power-on reset.

## GENERAL DESCRIPTION

The sound fader control circuit TEA6321 is an I²C-bus controlled stereo preamplifier for car radio hi-fi sound applications.

## QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | | 7.5 | 8.5 | 9.5 | V |
| $I_{CC}$ | supply current | $V_{CC}$ = 8.5 V | – | 26 | – | mA |
| $V_{o(rms)}$ | maximum output voltage level | $V_{CC}$ = 8.5 V; THD ≤ 0.1% | – | 2000 | – | mV |
| $G_v$ | voltage gain | | –86 | – | +20 | dB |
| $G_{step(vol)}$ | step resolution (volume) | | – | 1 | – | dB |
| $G_{bass}$ | bass control | | –18 | – | +18 | dB |
| $G_{treble}$ | treble control | | –12 | – | +12 | dB |
| $G_{step(treble)}$ | step resolution (treble) | | – | 1.5 | – | dB |
| (S+N)/N | signal-plus-noise to noise ratio | $V_o$ = 2.0 V; $G_v$ = 0 dB; unweighted | – | 105 | – | dB |
| $RR_{100}$ | ripple rejection | $V_{r(rms)}$ < 200 mV; f = 100 Hz; $G_v$ = 0 dB | – | 75 | – | dB |
| $\alpha_{cs}$ | channel separation | 250 Hz ≤ f ≤ 10 kHz; $G_v$ = 0 dB | 90 | 96 | – | dB |

## ORDERING INFORMATION

| TYPE NUMBER | PACKAGE | | |
|---|---|---|---|
| | NAME | DESCRIPTION | VERSION |
| TEA6321T | SO32 | plastic small outline package; 32 leads; body width 7.5 mm | SOT287-1 |

## BLOCK DIAGRAM

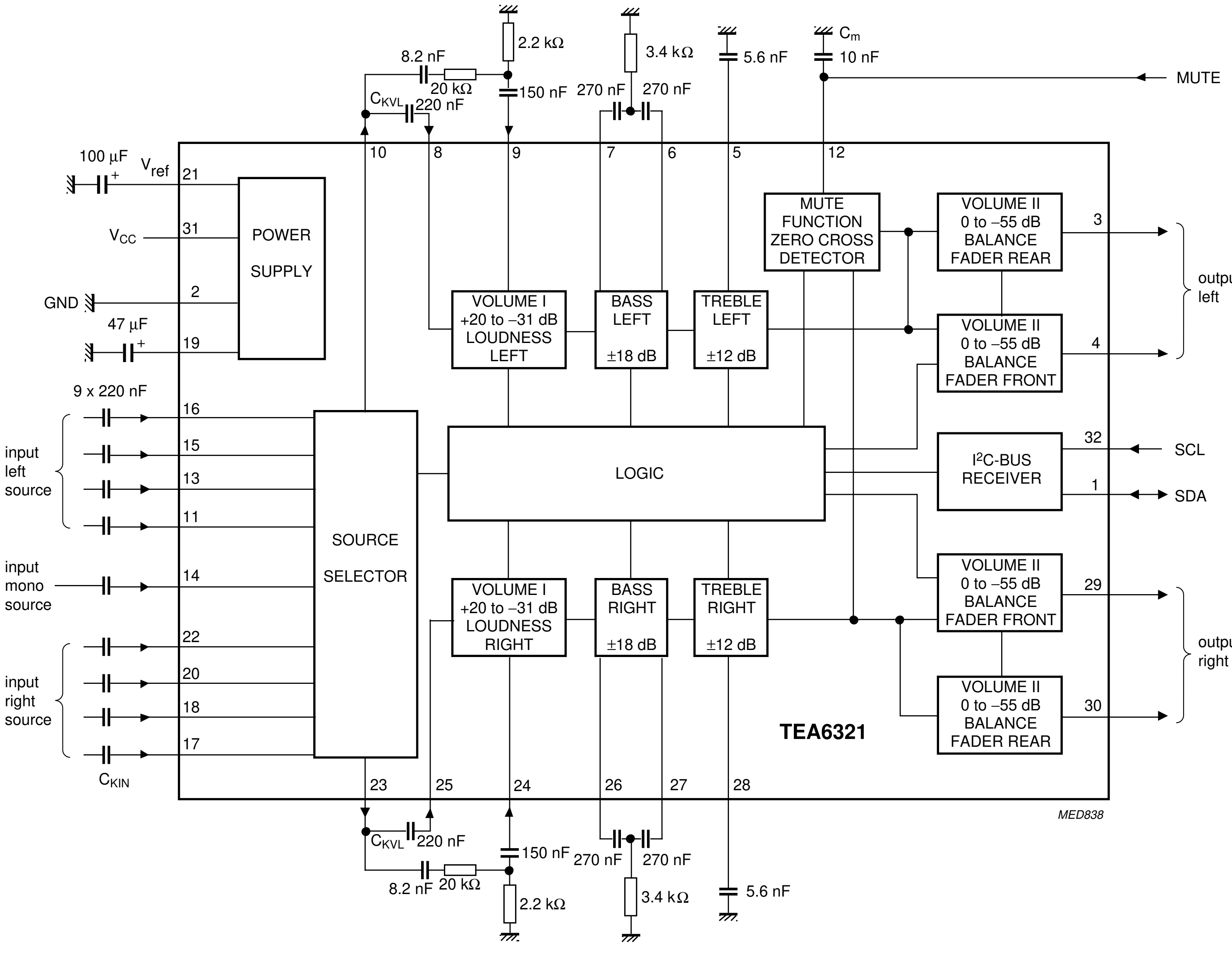



Fig.1 Block diagram.

## PINNING

| SYMBOL | PIN | DESCRIPTION |
|---|---|---|
| SDA | 1 | serial data input/output |
| GND | 2 | ground |
| OUTLR | 3 | output left rear |
| OUTLF | 4 | output left front |
| TL | 5 | treble control capacitor left channel or input from an external equalizer |
| B2L | 6 | bass control left channel or output to an external equalizer |
| B1L | 7 | bass control, left channel |
| IVL | 8 | input volume I, left control part |
| ILL | 9 | input loudness, left control part |
| QSL | 10 | output source selector, left channel |
| IDL | 11 | input D left source |
| MUTE | 12 | mute control |
| ICL | 13 | input C left source |
| IMO | 14 | input mono source |
| IBL | 15 | input B left source |
| IAL | 16 | input A left source |
| IAR | 17 | input A right source |
| IBR | 18 | input B right source |
| CAP | 19 | electronic filtering for supply |
| ICR | 20 | input C right source |
| $V_{ref}$ | 21 | reference voltage ($0.5V_{CC}$) |
| IDR | 22 | input D right source |
| QSR | 23 | output source selector right channel |
| ILR | 24 | input loudness right channel |
| IVR | 25 | input volume I, right control part |
| B1R | 26 | bass control right channel |
| B2R | 27 | bass control right channel or output to an external equalizer |
| TR | 28 | treble control capacitor right channel or input from an external equalizer |
| OUTRF | 29 | output right front |
| OUTRR | 30 | output right rear |
| $V_{CC}$ | 31 | supply voltage |
| SCL | 32 | serial clock input |

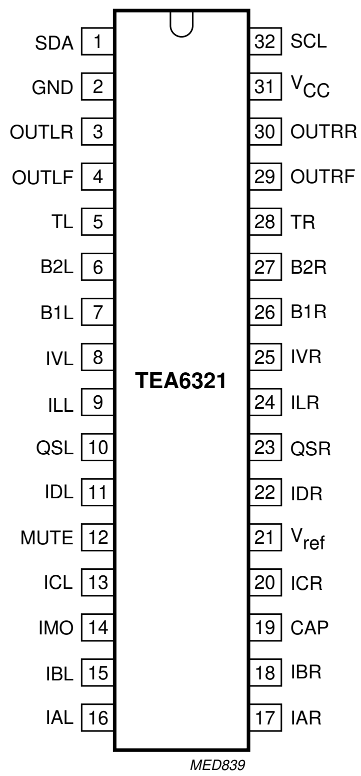



Fig.2 Pin configuration.

## FUNCTIONAL DESCRIPTION

The source selector selects one of 4 stereo inputs or the mono input. 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 8 and 10 for the left channel and pins 23 and 25 for the right channel. This offers the possibility of interfacing a noise reduction system.

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 I²C-bus control (see Table 7).

The volume I control block 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 I²C-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.

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 I²C-bus using 2 independent zero crossing detectors (ZCM, see Tables 2 and 9 and Fig.16).
2. Fast mute via MUTE pin (see Fig.10).
3. Fast mute via I²C-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, the maximum delay time is limited to typically 100 ms by an integrated timing circuit and an external capacitor ($C_m$ = 10 nF, see Fig.10). This timing circuit is triggered by reception of a new data word for the switch function which includes the GMU bit. After a discharge and charge period of an external capacitor the muting switch follows the GMU bit if no zero crossing was detected during that time.

The mute function can also be controlled externally. If the mute pin is switched to ground all outputs are muted immediately (hardware mute). This mute request overwrites all mute controls via the I²C-bus for the time the pin is held LOW. The hardware mute position is not stored in the TEA6321.

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 $V_{CC}$, the mute has to be set before the $V_{CC}$ will drop. This can be achieved by I²C-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 × $V_{BE}$ will result in a mute during the voltage drop.

The power supply should include a $V_{CC}$ 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 $V_{CC}$ 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 plops. 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 |
|---|---|---|---|---|---|
| $V_{CC}$ | supply voltage | | 0 | 10 | V |
| $V_n$ | voltage at pins 1 and 3 to 32 to pin 2 | | 0 | $V_{CC}$ | V |
| $T_{amb}$ | operating ambient temperature | | –40 | +85 | °C |
| $T_{stg}$ | storage temperature | | –65 | +150 | °C |
| $V_{es}$ | 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.

## CHARACTERISTICS

$V_{CC}$ = 8.5 V; $R_S$ = 600 Ω; $R_L$ = 10 kΩ; $C_L$ = 2.5 nF; AC coupled; f = 1 kHz; $T_{amb}$ = 25 °C; gain control $G_v$ = 0 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 21 | | – | 4.25 | – | V |
| $G_{v(max)}$ | maximum voltage gain | $R_S$ = 0 Ω; $R_L$ = ∞ | 19 | 20 | 21 | dB |
| $V_{o(rms)}$ | output voltage level for | | | | | |
| | $P_{max}$ at the power output stage | THD ≤ 0.1%; see Fig.11 | – | 2000 | – | mV |
| | start of clipping | THD = 1% | 2300 | – | – | mV |
| | | $R_L$ = 2 kΩ; $C_L$ = 10 nF; THD = 1% | 2000 | – | – | mV |
| $V_{i(rms)}$ | input sensitivity | $V_o$ = 2000 mV; $G_v$ = 20 dB | – | 200 | – | mV |
| $f_{ro}$ | roll-off frequency | $C_{KIN}$ = 220 nF; $C_{KVL}$ = 220 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 nF; $C_{KVL}$ = 100 nF; $Z_i$ = $Z_{i(typ)}$ low frequency (–3 dB) | 17 | – | – | Hz |
| $\alpha_{cs}$ | channel separation | $V_i$ = 2 V; frequency range 250 Hz to 10 kHz | 90 | 96 | – | dB |
| THD | total harmonic distortion | frequency range 20 Hz to 12.5 kHz | | | | |
| | | $V_i$ = 100 mV; $G_v$ = 20 dB | – | 0.1 | – | % |
| | | $V_i$ = 1 V; $G_v$ = 0 dB | – | 0.05 | 0.15 | % |
| | | $V_i$ = 2 V; $G_v$ = 0 dB | – | 0.1 | – | % |
| | | $V_i$ = 2 V; $G_v$ = –10 dB | – | 0.1 | – | % |
| RR | ripple rejection | $V_{r(rms)}$ < 200 mV | | | | |
| | | f = 100 Hz | 70 | 76 | – | dB |
| | | f = 40 Hz to 12.5 kHz | – | 66 | – | dB |
| (S+N)/N | signal-plus-noise to noise ratio | unweighted; 20 Hz to 20 kHz RMS; $V_o$ = 2.0 V; see Figs 6 and 7 | – | 105 | – | dB |
| | | CCIR468-2 weighted; 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 |

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $P_{no(rms)}$ | noise output power (RMS value) only contribution of TEA6321; power amplifier for 6 W | mute position; note 1 | – | – | 10 | nW |
| $\alpha_{ct}$ | crosstalk $\left(20\ \log\frac{V_{bus\,(p-p)}}{V_{o\,(rms)}}\right)$ between bus inputs and signal outputs | note 2 | – | 110 | – | dB |
| **Source selector** | | | | | | |
| $Z_i$ | input impedance | | 25 | 35 | 45 | kΩ |
| $\alpha_S$ | input isolation of one selected source to any other input | f = 1 kHz | – | 105 | – | dB |
| | | f = 12.5 kHz | – | 95 | – | dB |
| $V_{i(rms)}$ | maximum input voltage (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 output by selection of any inputs | | – | – | 10 | mV |
| $Z_o$ | output impedance | | – | 80 | 120 | Ω |
| $R_L$ | output load resistance | | 10 | – | – | kΩ |
| $C_L$ | output load capacity | | 0 | – | 2500 | pF |
| $G_v$ | voltage gain, source selector | | – | 0 | – | dB |
| **Control part (source selector disconnected; source resistance 600 Ω)** | | | | | | |
| $Z_i$ | input impedance volume input | | 100 | 150 | 200 | kΩ |
| | input impedance loudness input | | 25 | 33 | 40 | kΩ |
| $Z_o$ | output impedance | | – | 80 | 120 | Ω |
| $R_L$ | output load resistance | | 2 | – | – | kΩ |
| $C_L$ | output load capacity | | 0 | – | 10 | nF |
| $R_{DCL}$ | DC load resistance at output to ground | | 4.7 | – | – | kΩ |
| $V_{i(rms)}$ | maximum input voltage (RMS value) | THD < 0.5% | – | 2.15 | – | V |
| $V_{no}$ | noise output voltage | CCIR468-2 weighted; quasi peak | | | | |
| | | $G_v$ = 20 dB | – | 110 | 220 | μV |
| | | $G_v$ = 0 dB | – | 33 | 50 | μV |
| | | $G_v$ = –66 dB | – | 13 | 22 | μV |
| | | mute position | – | 10 | – | μV |
| $CR_{tot}$ | total continuous control range | | – | 106 | – | dB |
| | recommended control range | | – | 86 | – | dB |
| $G_{step}$ | step resolution | | – | 1 | – | dB |
| | step error between any adjoining step | | – | – | 0.5 | dB |

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $\Delta G_a$ | attenuator set error | $G_v$ = +20 to –50 dB | – | – | 2 | dB |
| | | $G_v$ = –51 to –66 dB | – | – | 3 | dB |
| $\Delta G_t$ | gain tracking error | $G_v$ = +20 to –50 dB | – | – | 2 | dB |
| $MUTE_{att}$ | mute attenuation | see Fig.10 | 100 | 110 | – | dB |
| $V_{offset}$ | DC step offset between any adjoining step | $G_v$ = 0 to –66 dB | – | 0.2 | 10 | mV |
| | | $G_v$ = 20 to 0 dB | – | 2 | 15 | mV |
| | DC step offset between any step to mute | $G_v$ = 0 to –66 dB | – | – | 10 | mV |
| **Volume I control and loudness** | | | | | | |
| $CR_{vol}$ | continuous volume control range | | – | 51 | – | dB |
| $G_v$ | voltage gain | | –31 | – | +20 | dB |
| $G_{step}$ | step resolution | | – | 1 | – | dB |
| $L_{Bmax}$ | maximum loudness boost | loudness on; referred to loudness off; boost is determined by external components | | | | |
| | | f = 40 Hz | – | 17 | – | dB |
| | | f = 10 kHz | – | 4.5 | – | dB |
| **Bass control** | | | | | | |
| $G_{bass}$ | bass control, maximum boost | f = 46 Hz | 16 | 18 | 19 | dB |
| | maximum attenuation | f = 46 Hz | 16 | 18 | 19 | dB |
| $G_{step}$ | step resolution (toggle switching) | f = 46 Hz | – | 1.8 | – | dB |
| | step error between any adjoining step | f = 46 Hz | – | – | 0.5 | dB |
| $V_{offset}$ | DC step offset in any bass position | | – | – | 20 | mV |
| **Treble control** | | | | | | |
| $G_{treble}$ | treble control, maximum boost | f = 15 kHz | 11 | 12 | 13 | dB |
| | maximum attenuation | f = 15 kHz | 11 | 12 | 13 | dB |
| | maximum boost | f > 15 kHz | – | – | 15 | dB |
| $G_{step}$ | step resolution (toggle switching) | f = 15 kHz | – | 1.5 | – | dB |
| | step error between any adjoining step | f = 15 kHz | – | – | 0.5 | dB |
| $V_{offset}$ | DC step offset in any treble position | | – | – | 10 | mV |
| **Volume II, balance and fader control** | | | | | | |
| CR | continuous attenuation fader and volume control range | | 53.5 | 55 | 56.5 | dB |
| $G_{step}$ | step resolution | | – | 1 | 2 | dB |
| | attenuation set error | | – | – | 1.5 | dB |

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| **Mute function** (see Fig.10) | | | | | | |
| HARDWARE MUTE | | | | | | |
| $V_{sw}$ | mute switch level ($2 \times V_{BE}$) | | – | 1.45 | – | V |
| *mute active* | | | | | | |
| $V_{swLOW}$ | input level | | – | – | 1.0 | V |
| $I_i$ | input current | $V_{swLOW} = 1$ V | –300 | – | – | μA |
| *mute passive: level internally defined* | | | | | | |
| $V_{swHIGH}$ | saturation voltage | | – | – | $V_{CC}$ | V |
| $t_{d(mute)}$ | delay until mute passive | | – | – | 0.5 | ms |
| ZERO CROSSING MUTE | | | | | | |
| $I_d$ | discharge current | | 0.3 | 0.6 | 1.2 | μA |
| $I_{ch}$ | charge current | | –300 | –150 | – | μA |
| $V_{swDEL}$ | delay switch level ($3 \times V_{BE}$) | | – | 2.2 | – | V |
| $t_d$ | delay time | $C_m = 10$ nF | – | 100 | – | ms |
| $V_{wind}$ | window for audio signal zero crossing detection | | – | 30 | 40 | mV |
| **Muting at power supply drop** | | | | | | |
| $V_{CCdrop}$ | supply drop for mute active | | – | $V_{19} - 0.7$ | – | V |
| **Power-on reset (when reset is active the GMU-bit (general mute) is set and the I²C-bus receiver is in reset position)** | | | | | | |
| $V_{CC}$ | 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 |
| **Digital part (I²C-bus pins);** note 3 | | | | | | |
| $V_{iH}$ | HIGH level input voltage | | 3 | – | 9.5 | V |
| $V_{iL}$ | LOW level input voltage | | –0.3 | – | +1.5 | V |
| $I_{iH}$ | HIGH level input current | | –10 | – | +10 | μA |
| $I_{iL}$ | LOW level input current | | –10 | – | +10 | μA |
| $V_{oL}$ | LOW level output voltage | $I_L = 3$ mA | – | – | 0.4 | V |

**Notes to the characteristics**

1. The indicated values for output power assume a 6 W power amplifier at 4 Ω 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 I²C-bus specification. This specification, *"The I²C-bus and how to use it"*, can be ordered using the code 9398 393 40011.

## $I^2C$-BUS PROTOCOL

### $I^2C$-bus format

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

**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.
6. P = STOP condition.

**Table 1** Second byte after MAD.

| FUNCTION | BIT | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|---|
| | | 7 | 6 | 5 | 4 | 3 | 2(1) | 1(1) | 0(1) |
| 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.

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

**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 the outputs OVL and OVR (general mute).
12. Source selector control.

**Table 3** Volume I setting

| $G_v$ (dB) | DATA | | | | | |
|---|---|---|---|---|---|---|
| | **V5** | **V4** | **V3** | **V2** | **V1** | **V0** |
| **Loudness on: the increment of the loudness characteristics is linear at every volume step in the range from +20 to −11 dB** | | | | | | |
| +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 |

| $G_v$ (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 |

**Table 4** Volume II setting (fader and balance); note 1

| $G_v$ (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 |

| $G_v$ (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 |

**Note**

1. For a particular range the data is always the same, only the subaddress changes.

**Table 5** Bass setting

| $G_{bass}$ (dB) | DATA | | | | |
|---|---|---|---|---|---|
| | BA4 | BA3 | BA2 | BA1 | BA0 |
| +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(1) | 1 | 0 | 0 | 0 | 1 |
| 0(2) | 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.

**Table 6** Treble setting

| $G_{treble}$ (dB) | DATA | | | | |
|---|---|---|---|---|---|
| | TR4 | TR3 | TR2 | TR1 | TR0 |
| +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(1) | 1 | 0 | 0 | 0 | 1 |
| 0(2) | 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.

**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 |
| Mono input IMO | 0 | X(1) | X(1) |

**Note**

1. X = don't care bits (logic 1 during testing).

**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 |

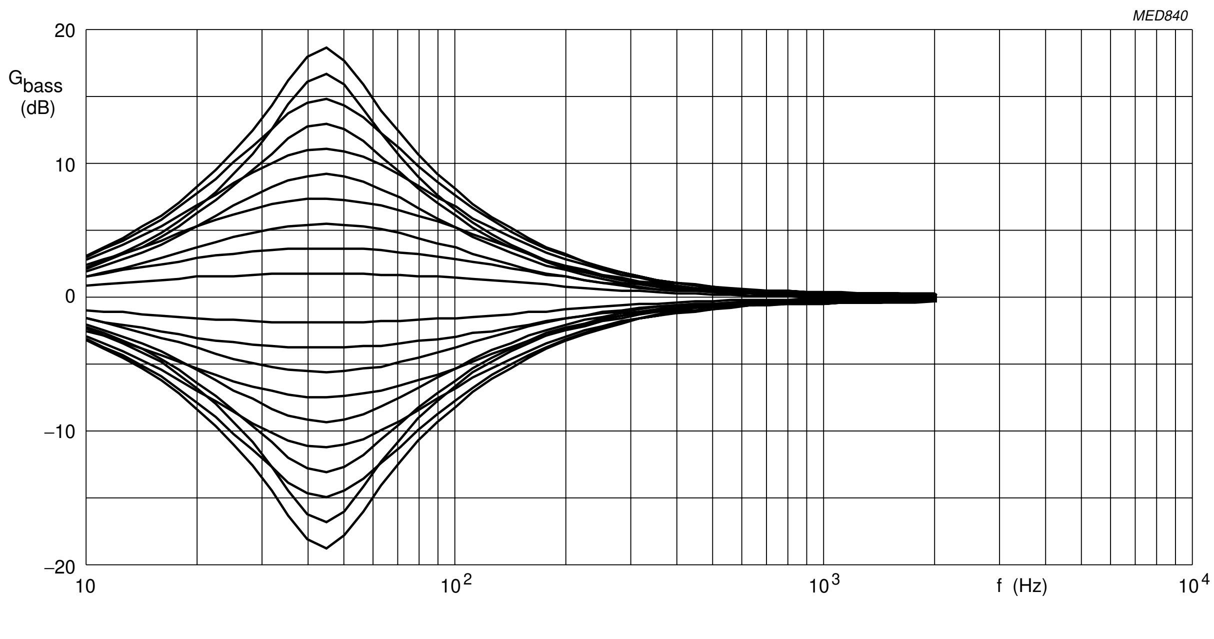



Fig.3 Bass control.

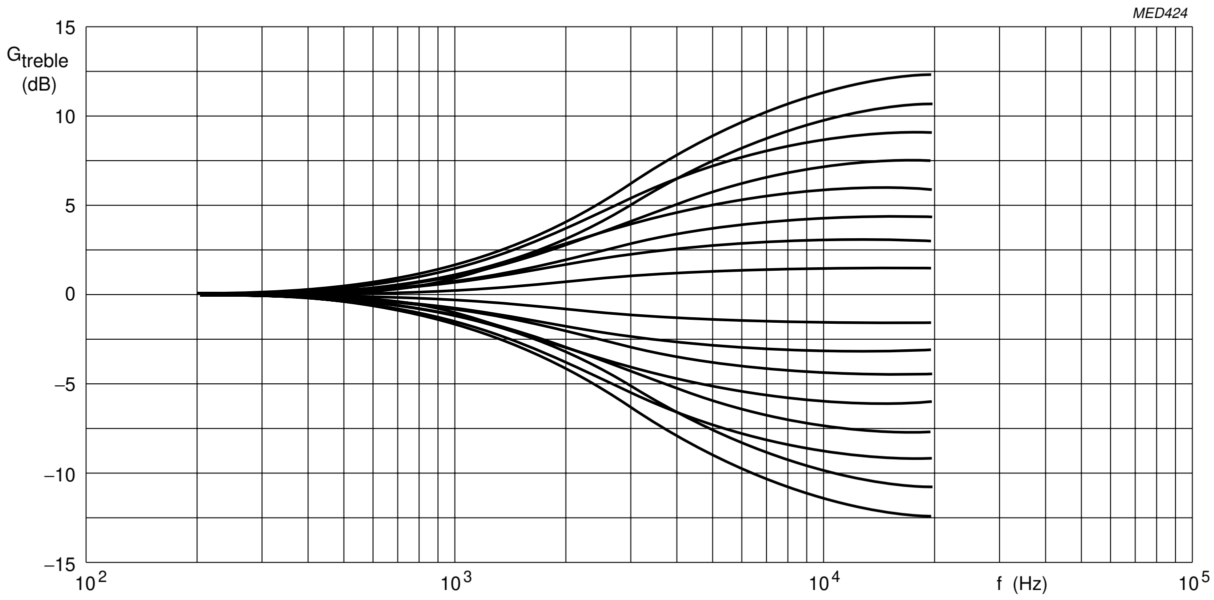



Fig.4 Treble control.

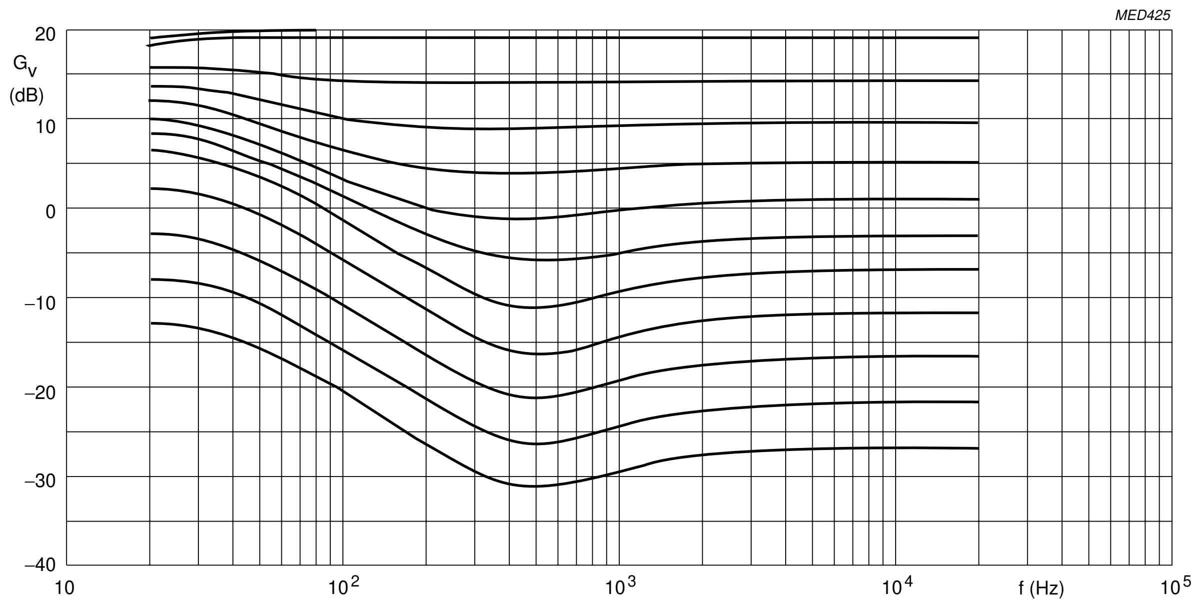
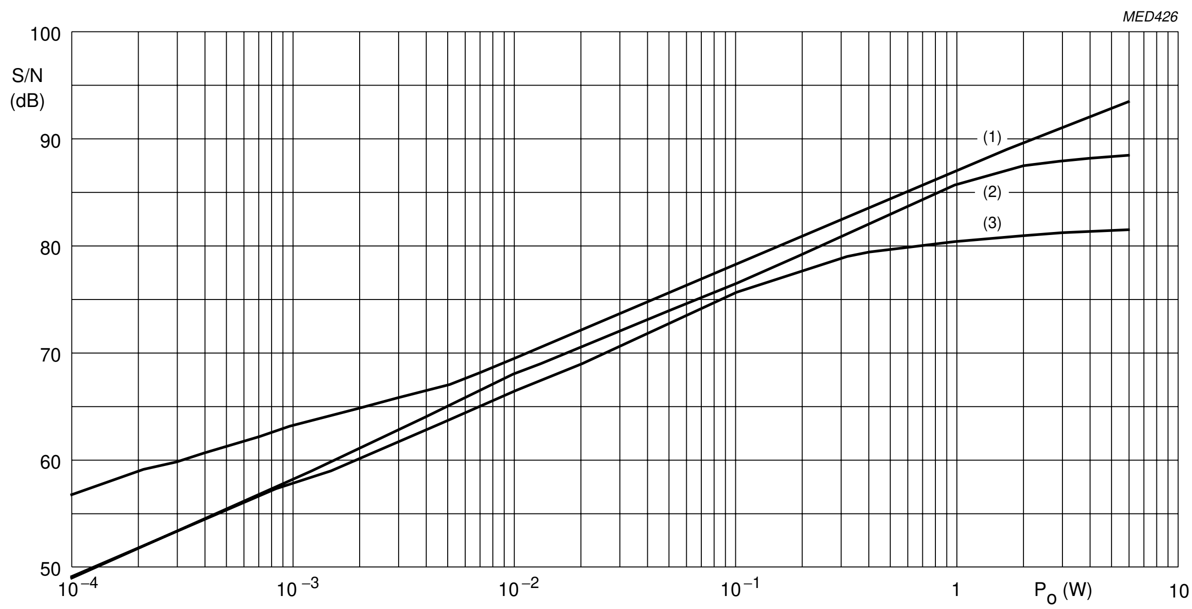
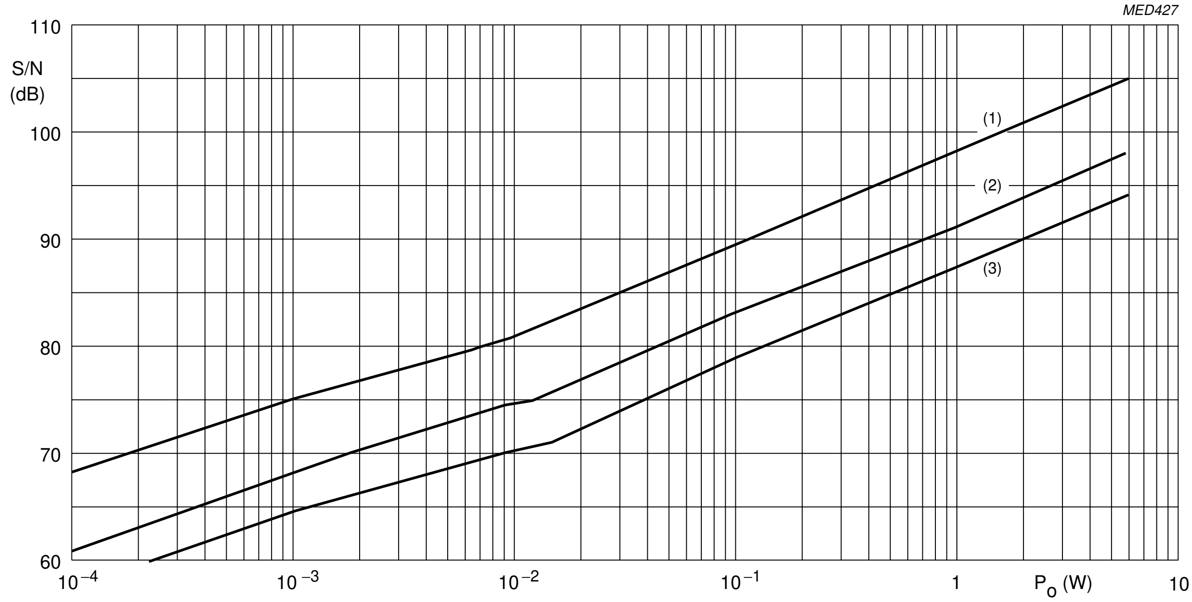



Fig.5 Volume control with loudness (including low roll-off frequency).



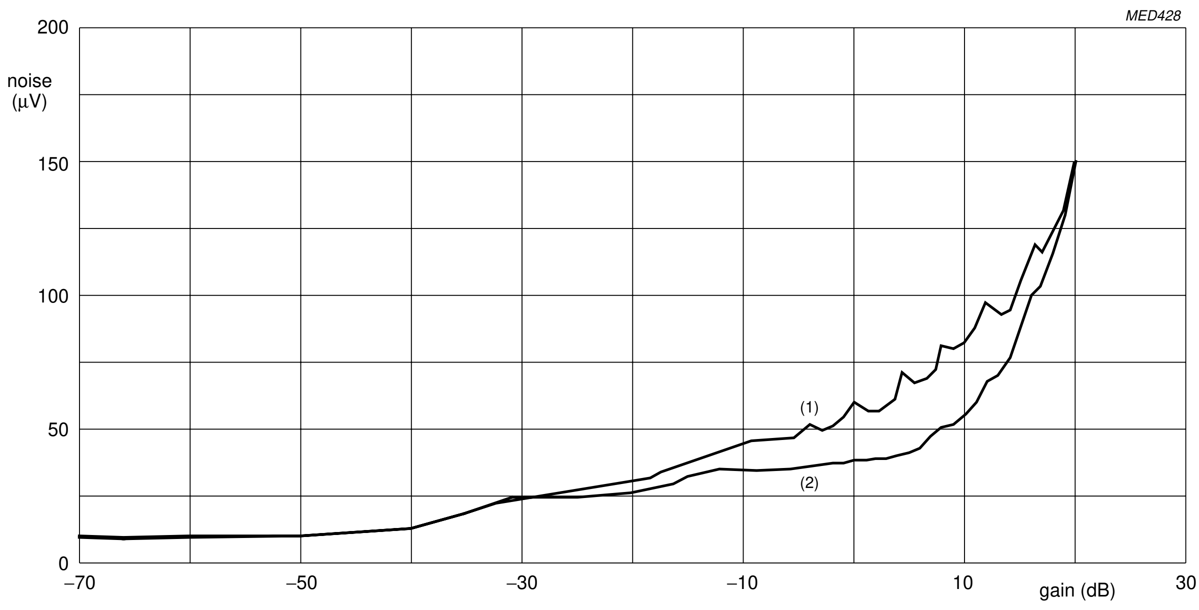

(1) $V_i$ = 2.0 V.
(2) $V_i$ = 0.5 V.
(3) $V_i$ = 0.2 V.

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




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

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




Stereo/mono inputs.
(1) Loudness on.
(2) Loudness off.

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

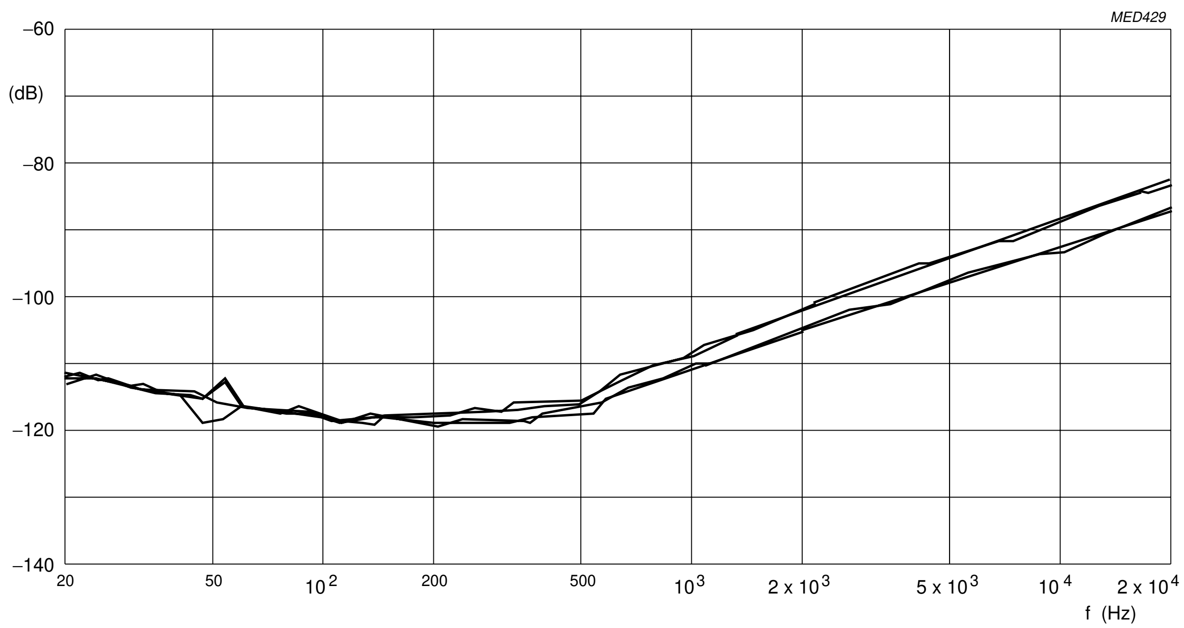
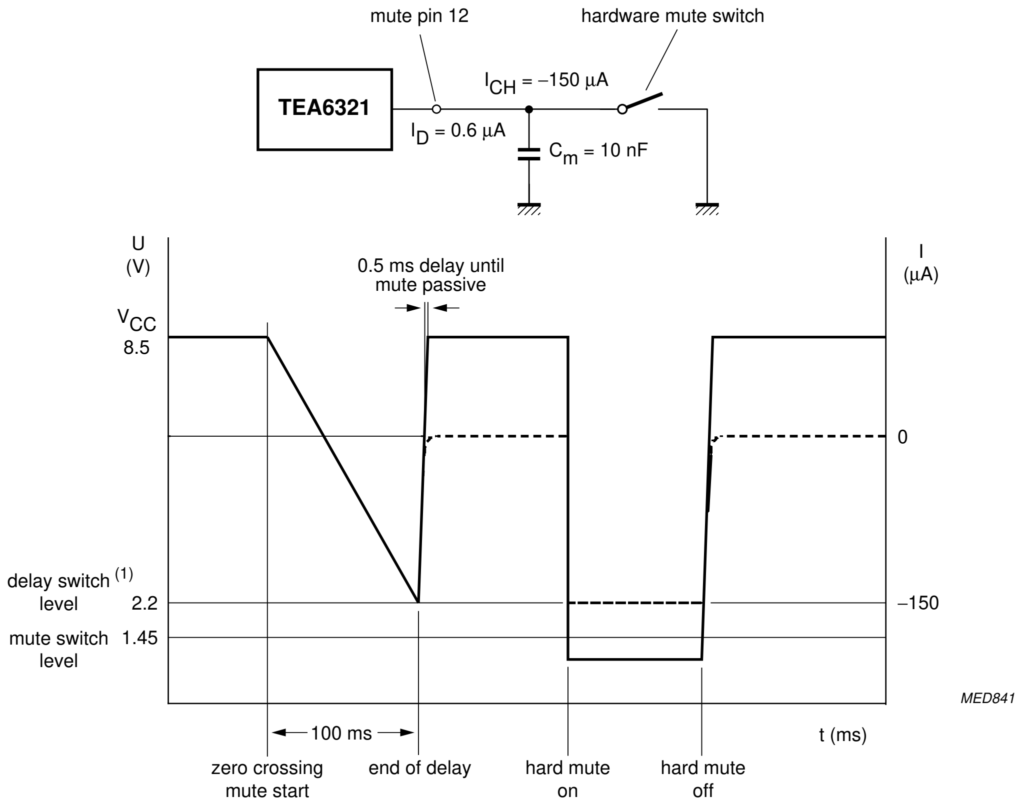


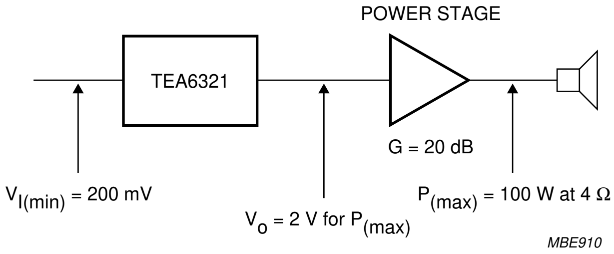

Fig.9 Muting.



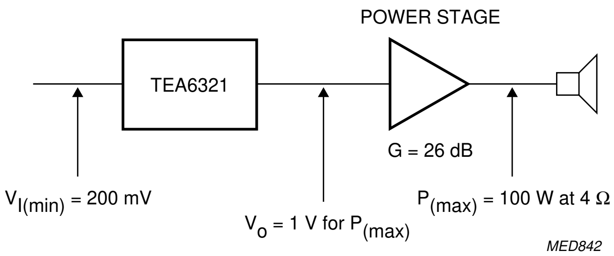

(1) Typically 2.2 V; referenced to 3 × $V_{BE}$

Fig.10 Mute function diagram.

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.11 Level diagram.

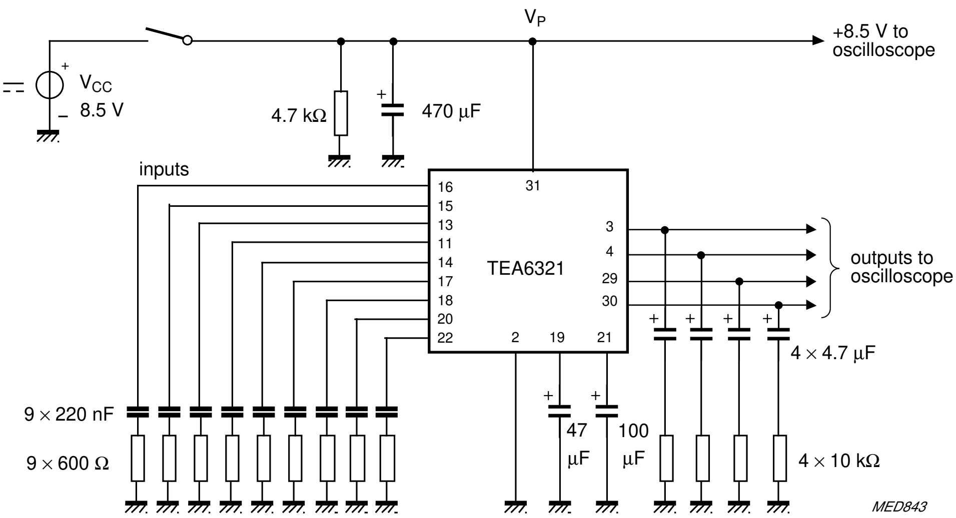
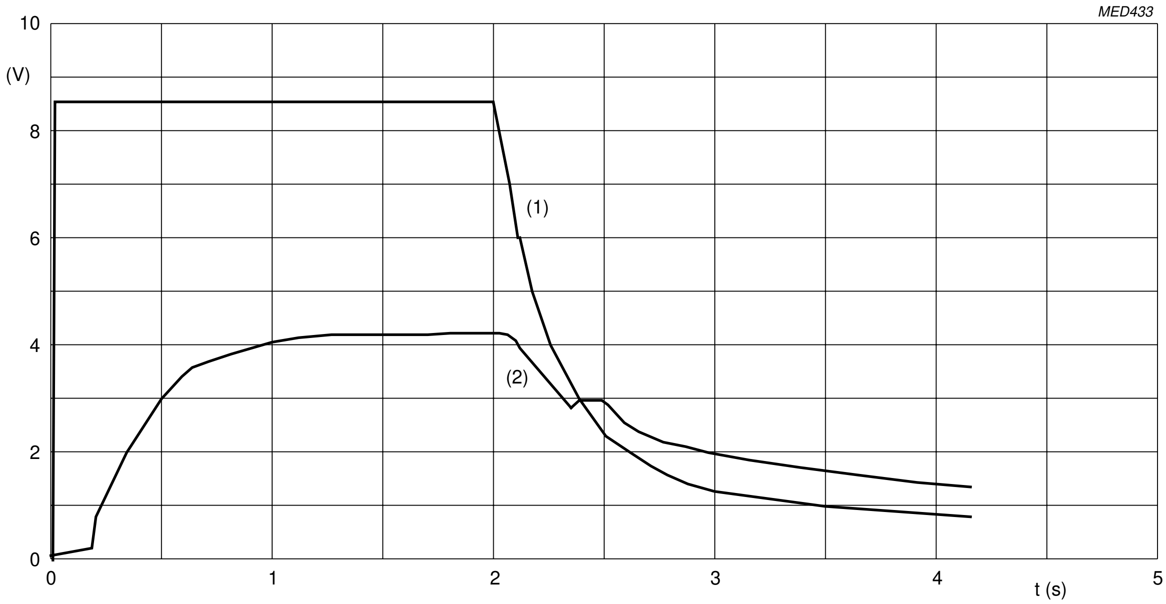



Fig.12 Turn-on/off power supply circuit diagram.




(1) $V_{CC}$.
(2) $V_O$.

Fig.13 Turn-on/off behaviour.