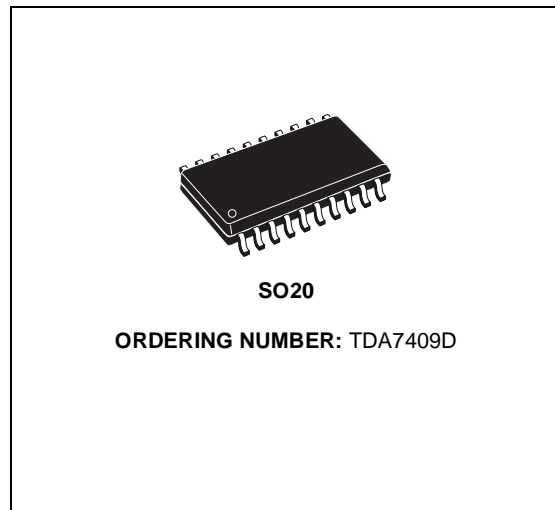


CARRADIO-SIGNAL-PROCESSOR

- 4 STEREO INPUTS
- SOFT STEP-VOLUME
- BASS, TREBLE AND LOUDNESS CONTROL
- DIRECT MUTE AND SOFT MUTE
- INTERNAL BEEP
- FOUR INDEPENDENT SPEAKER-OUTPUTS
- SUBWOOFER STEREO OUTPUT
- DIGITAL CONTROL:
 - I²C-BUS INTERFACE
 - AUDIO-FILTER CHARACTERISTICS PROGRAMMABLE

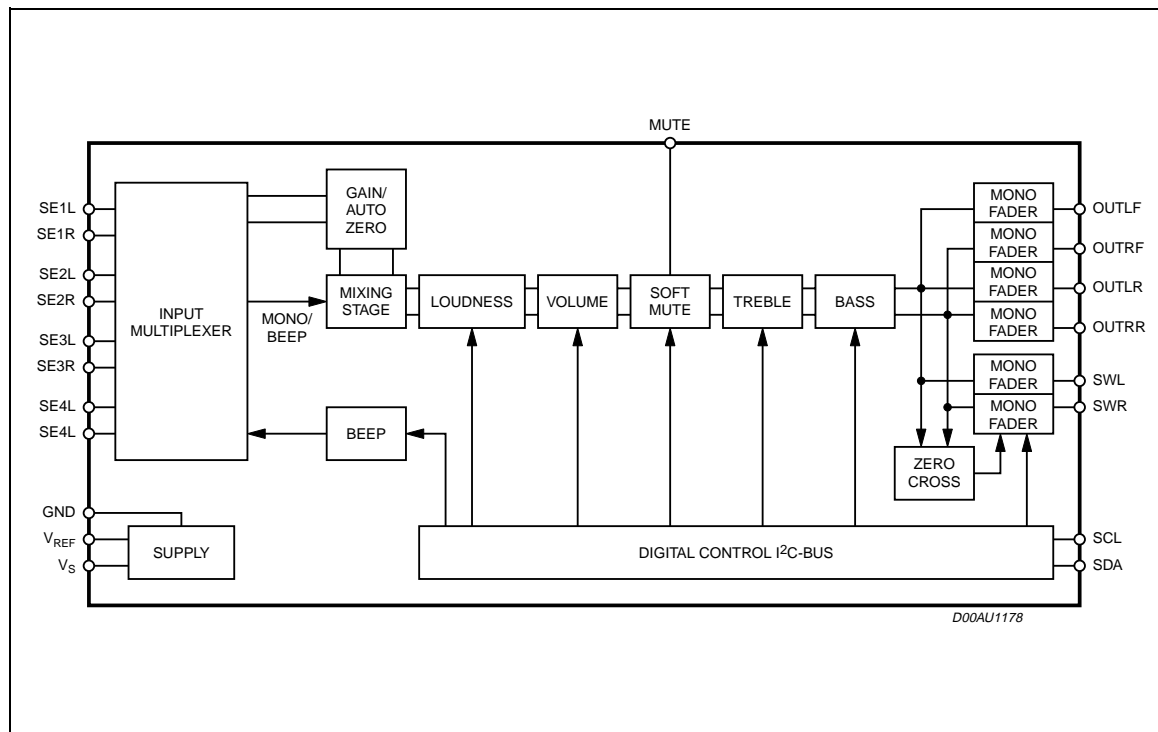


DESCRIPTION

The TDA7409 is a high performance signal processor specifically designed for car radio applications. The device includes a high performance audioprocessor with fully integrated audio filters. The digital control allows a programming in a wide range of all the filter characteristics. By the use of a BICMOS-

process and a linear signal processing low distortion and low noise are obtained.

BLOCK DIAGRAM



TDA7409

SUPPLY

| Symbol | Parameter | Test Condition | Min. | Typ. | Max. | Unit |
|--------|-------------------------|----------------------------------|------|------|------|------|
| V_s | Supply Voltage | | 7.5 | 9 | 10.5 | V |
| I_s | Supply Current | $V_s = 9V$ | | 20 | | mA |
| SVRR | Ripple Rejection @ 1KHz | Audioprocessor(all Filters flat) | | 60 | | dB |

THERMAL DATA

| Symbol | Parameter | Value | Unit |
|------------------|--------------------------------------|-------|------|
| $R_{Th\ j-pins}$ | Thermal Resistance Junction-pins max | 85 | °C/W |

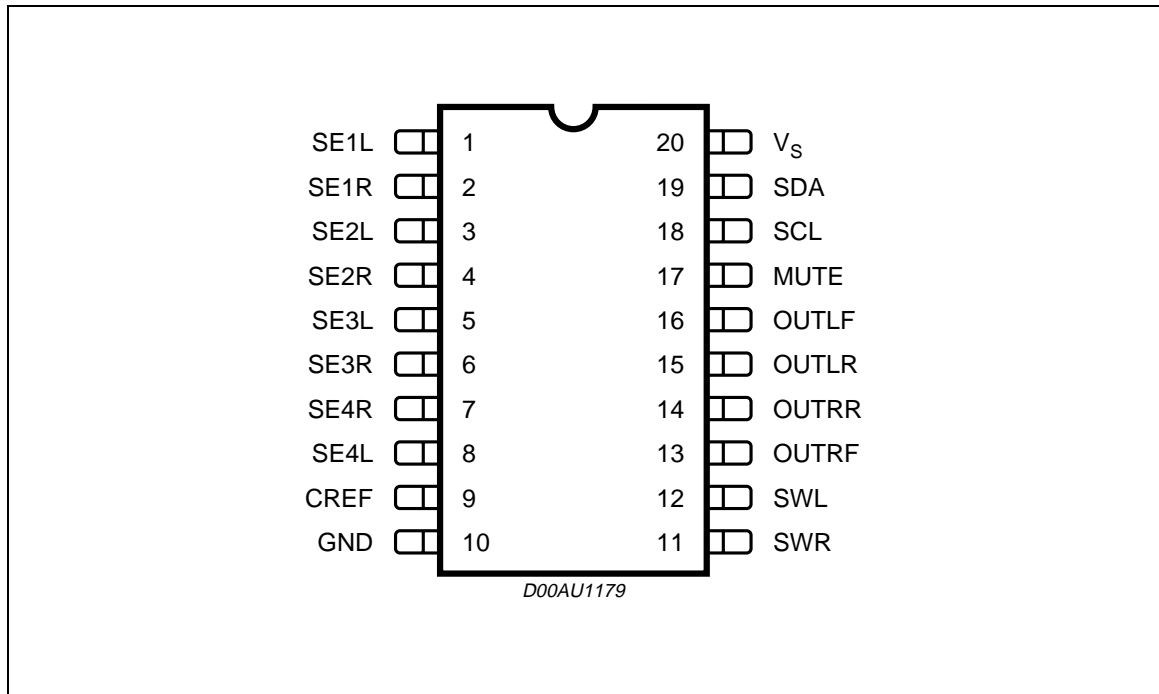
ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Value | Unit |
|-----------|-----------------------------|-------------|------|
| V_s | Operating Supply Voltage | 10.8 | V |
| T_{amb} | Operating Temperature Range | -40 to 85 | °C |
| T_{stg} | Storage Temperature Range | -55 to +150 | °C |

ESD

All pins are protected against ESD according to the MIL883 standard.

PIN CONNECTION



FEATURES:

| | |
|-------------------|---|
| Input Multiplexer | 4 single-end stereo inputs In-Gain 0..14dB, 1dB steps, 14..20dB, 2dB steps Auto Zero |
| Beep | internal Beep with 3 frequencies 781Hz/1.56KHz/1.8KHz |
| Mixing stage | 4 step-mixing-stage with mono or beep as mix-signals |
| Loudness | second order frequency response programmable center frequency 15 x 1dB steps selectable low & high frequency boost selectable flat-mode (constant attenuation) |
| Volume | 1 dB attenuator 100dB range soft-step control with programmable times |
| Bass | 2nd order frequency response center frequency programmable in 4 steps 60Hz/80Hz/100Hz/200Hz Q programmable 1.0/1.25/1.5/2.0 DC gain programmable $\pm 15\text{dB} \times 1\text{dB steps}$ |
| Treble | 2nd order frequency response center frequency programmable in 4 steps 10KHz/12.5KHz/15KHz/17.5KHz $\pm 15\text{dB} \times 1\text{dB steps}$ |
| Speaker | 4 independent speaker controls in 1dB steps control range 50dB with mute Zero crossing attenuate |
| Subwoofer | Stereo output attenuator range 50dB |
| Mute Functions | direct mute digitally controlled Soft Mute with 4 programmable mute-times |

TDA7409

ELECTRICAL CHARACTERISTICS ($V_S=9V$; $T_{AMB}=25$; $R_L=10k\Omega$; all gains = 0dB; $f = 1kHz$; unless otherwise specified)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|--------|-----------|-----------------|------|------|------|------|
|--------|-----------|-----------------|------|------|------|------|

INPUT SELECTOR

| | | | | | | |
|---------------|--------------------------------|-------------------------|------|------|-----|-----------|
| R_{in} | Input Resistance | all single ended Inputs | 70 | 100 | 130 | $k\Omega$ |
| V_{CL} | Clipping Level | | 2.20 | 2.60 | | V_{RMS} |
| S_{IN} | Input Separation | | 80 | 100 | | dB |
| $G_{IN\ MIN}$ | Min. Input Gain | | -1 | 0 | 1 | dB |
| $G_{IN\ MAX}$ | Max. Input Gain | | 18 | 20 | 22 | dB |
| G_{STEP} | Step Resolution | | 0.5 | 1 | 1.5 | dB |
| V_{DC} | DC Steps | Adjacent Gain Steps | -5 | 1 | 5 | mV |
| | | G_{MIN} to G_{MAX} | -10 | 5 | 10 | mV |
| V_{offset} | Remaining offset with AutoZero | | | 0.5 | | mV |

BEEP CONTROL

| | | | | | | |
|-----------|----------------|----------|------|------|------|-----|
| V_{RMS} | Beep Level | | 250 | 350 | 500 | mV |
| f_B | Beep Frequency | f_{B1} | 740 | 781 | 820 | Hz |
| | | f_{B2} | 1.48 | 1.56 | 1.64 | kHz |
| | | f_{B3} | 1.7 | 1.8 | 1.9 | kHz |

MIXING CONTROL

| | | | | | | |
|-------------|--------------|-------------------|------------|-----------|-----------|----|
| M_{LEVEL} | Mixing Level | Main / Mix-Source | | 0/00 | | dB |
| | | Main / Mix-Source | -0.5/-10.6 | -3.5/-9.6 | -2.5/-8.6 | dB |
| | | Main / Mix-Source | -5/-5 | -6/-6 | -7/-7 | dB |
| | | Main / Mix-Source | -11/-1.5 | -12/-2.5 | -13/-3.5 | dB |

VOLUME CONTROL

| | | | | | | |
|------------|-----------------------|-----------------------|-----|-----|-----|----|
| G_{MAX} | Max. Gain | | 28 | 30 | 32 | dB |
| A_{MAX} | Max. Attenuation | | -83 | -79 | -75 | dB |
| A_{STEP} | Step Resolution | | 0.5 | 1 | 1.5 | dB |
| E_A | Attenuation Set Error | $G = -20$ to $+20$ dB | -1 | 0 | 1 | dB |
| | | $G = -80$ to -20 dB | -4 | 0 | 3 | dB |
| E_T | Tracking Error | | | | 2 | dB |

ELECTRICAL CHARACTERISTICS (continued)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|-----------------|-----------|------------------------------|------|------|------|------|
| V _{DC} | DC Steps | Adjacent Steps | | 0.1 | 3 | mV |
| | | From 0dB to G _{MIN} | | 0.5 | 5 | mV |

LOUDNESS CONTROL

| | | | | | | |
|-------------------|------------------|--|-----|------------------|-----|-----|
| A _{STEP} | Step Resolution | | 0.5 | 1 | 1.5 | dB |
| A _{MAX} | Max. Attenuation | | 13 | 15 | 17 | dB |
| f _C | Center Frequency | | 360 | 400 | 440 | Hz |
| | | | 720 | 800 | 880 | Hz |
| | | | 2.3 | 2.4 ¹ | 2.5 | kHz |

SOFT MUTE

| | | | | | | |
|----------------------|---------------------------------------|----|------|------|-----|----|
| A _{MUTE} | Mute Attenuation | | 80 | 100 | | dB |
| T _D | Delay Time | T1 | | 0.48 | 1 | ms |
| | | T2 | | 0.96 | 2 | ms |
| | | T3 | 20 | 30.7 | 50 | ms |
| | | T4 | 70 | 123 | 170 | ms |
| V _{TH low} | Low Threshold for SM-Pin ² | | | | 1 | V |
| V _{TH high} | High Threshold for SM - Pin | | 2.50 | | | V |
| R _{PU} | Internal pull-up resistor | | 70 | 100 | 130 | kΩ |
| V _{PU} | Pull-Up Voltage | | | 5 | | V |

SOFT STEP

| | | | | | | |
|-----------------|-------------|------------------|--|------|--|----|
| T _{SW} | Switch time | T _{SW1} | | 0.68 | | ms |
| | | T _{SW2} | | 1.26 | | ms |
| | | T _{SW3} | | 2.52 | | ms |
| | | T _{SW4} | | 5.04 | | ms |

1) Center frequency 2.4kHz makes 1kHz bottom frequency at low & high frequency boost condition.

2) The SM-Pin is active low (Mute = 0)

BASS CONTROL

| | | | | | | |
|--------------------|------------------|-----------------|-----|-----|-----|----|
| C _{RANGE} | Control Range | | ±14 | ±15 | ±16 | dB |
| A _{STEP} | Step Resolution | | 0.5 | 1 | 1.5 | dB |
| f _C | Center Frequency | f _{C1} | 54 | 60 | 66 | Hz |
| | | f _{C2} | 72 | 80 | 88 | Hz |
| | | f _{C3} | 90 | 100 | 110 | Hz |
| | | f _{C4} | 180 | 200 | 220 | Hz |

ELECTRICAL CHARACTERISTICS (continued)

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|--------|----------------|-----------------|------|------|------|------|
| QBASS | Quality Factor | Q ₁ | 0.9 | 1 | 1.1 | |
| | | Q ₂ | 1.1 | 1.25 | 1.4 | |
| | | Q ₃ | 1.3 | 1.5 | 1.7 | |
| | | Q ₄ | 1.8 | 2 | 2.2 | |
| DCGAIN | Bass-DC-Gain | DC = off | -1 | 0 | 1 | dB |
| | | DC = on | 4 | 4.4 | 6 | dB |

TREBLE CONTROL

| | | | | | | |
|----------------|------------------|-----------------|-----|------|-----|-----|
| CRANGE | Control Range | | ±14 | ±15 | ±16 | dB |
| ASTEP | Step Resolution | | 0.5 | 1 | 1.5 | dB |
| f _C | Center Frequency | f _{C1} | 8 | 10 | 12 | kHz |
| | | f _{C2} | 10 | 12.5 | 15 | kHz |
| | | f _{C3} | 12 | 15 | 18 | kHz |
| | | f _{C4} | 14 | 17.5 | 21 | kHz |

SPEAKER ATTENUATORS

| | | | | | | |
|-----------------|-------------------------|---------------------------------|-----|------|-----|----|
| CRANGE | Control Range | | -53 | 50 | -47 | dB |
| ASTEP | Step Resolution | only for attenuation up to 24dB | 0.5 | 1 | 1.5 | dB |
| AMUTE | Output Mute Attenuation | | 80 | 90 | | dB |
| E _E | Attenuation Set Error | | -2 | | 2 | dB |
| V _{DC} | DC Steps | Adjacent Attenuation Steps | | 0.10 | 5 | mV |
| T _{ZC} | Zero Cross Timer | Data bit D1=1 , D2=1 | 29 | 37 | 45 | ms |
| V _{th} | Zero Cross Threshold | | | ±20 | | mV |

FADER OUTPUTS

| | | | | | | |
|-------------------|-------------------------|----------|------|------|-----|------------------|
| V _{CLIP} | Clipping Level | d = 0.3% | 2.20 | 2.60 | | V _{RMS} |
| R _L | Output Load Resistance | | 2 | | | kΩ |
| C _L | Output Load Capacitance | | | | 10 | nF |
| R _{OUT} | Output Impedance | | | 30 | 100 | Ω |
| V _{DC} | DC Voltage Level | | 4.3 | 4.5 | 4.7 | V |

SUBWOOFER ATTENUATORS

| | | | | | | |
|--------|-------------------------|--|-----|----|-----|----|
| CRANGE | Control Range | | -53 | 50 | -47 | dB |
| ASTEP | Step Resolution | | 0.5 | 1 | 1.5 | dB |
| AMUTE | Output Mute Attenuation | | 80 | 90 | | dB |

ELECTRICAL CHARACTERISTICS (continued)

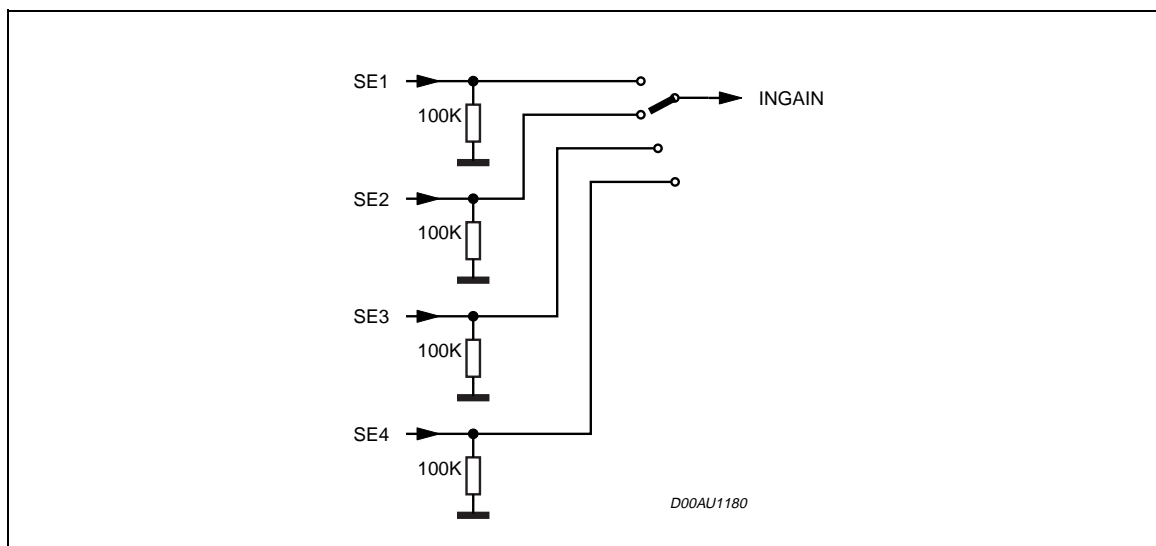
| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|----------|-----------------------|----------------------------|------|------|------|------|
| E_E | Attenuation Set Error | | | | 2 | dB |
| V_{DC} | DC Steps | Adjacent Attenuation Steps | | 0.10 | 5 | mV |

GENERAL

| | | | | | | |
|----------|-------------------------------|--|----|-------|-----|---------|
| e_{NO} | Output Noise | BW = 20Hz - 20kHz all gains = 0dB single ended inputs | | 10 | 15 | μV |
| S/N | Signal to Noise Ratio | all gains = 0dB flat; $V_O = 2V_{RMS}$ | | 106 | | dB |
| | | bass, treble at +12dB; a-weighted; $V_O = 2.6V_{RMS}$ | | 100 | | dB |
| d | Distortion | $V_{IN} = 1V_{RMS}$; all stages 0dB internal pass only | | 0.005 | 0.1 | % |
| | | $V_{OUT} = 1V_{RMS}$; Bass & Treble = 12dB | | 0.05 | 0.1 | % |
| S_C | Channel Separation left/right | | 80 | 100 | | dB |
| E_T | Total Tracking Error | $A_V = 0$ to -20dB | -1 | 0 | 1 | dB |
| | | $A_V = -20$ to -60dB | -2 | 0 | 2 | dB |

1.0 DESCRIPTION OF FUNCTIONALITY**1.1 Input stages**

The input stages have remained the same as in preceding ST-Audioprocessors.

Figure 1. Input-stages

1.2 AutoZero

In order to reduce the number of pins there is no AC coupling between the In-Gain and the following stage, so that any offset generated by or before the In-Gain-stage would be transferred or even amplified to the output. To avoid that effect a special Offset-cancellation-stage called AutoZero is implemented. This stage is located before the Mixing-block to eliminate all offsets generated by the Input-Stages and the In-Gain (Please notice that externally generated offsets, e.g. generated through the leakage current of the coupling capacitors, are not canceled).

The auto-zeroing is started every time the DATA-BYTE 0 (Input Selector/Gain) is selected and takes a time of max. **0.3ms**. To avoid audible clicks the Audioprocessor is muted before the loudness stage during this time.

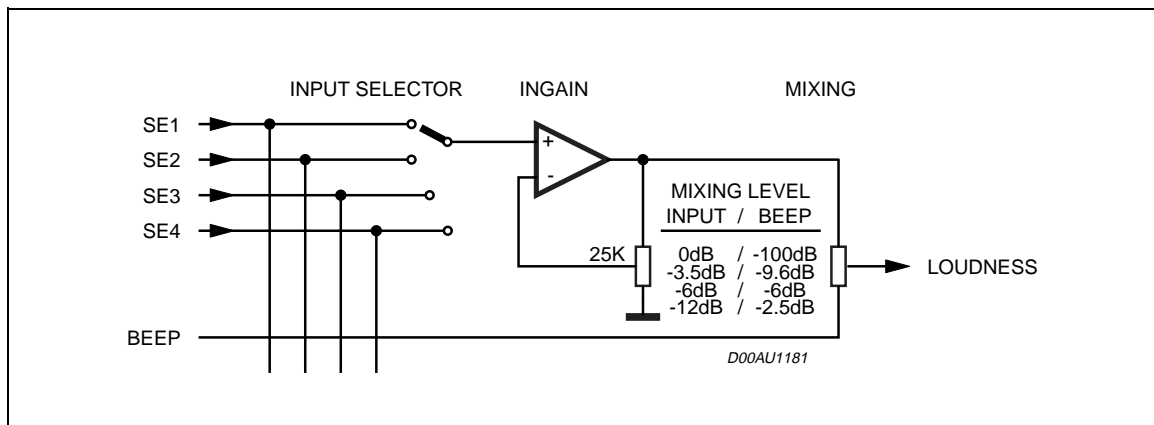
1.2.1 AutoZero-Remain

In some cases, for example if the uP is executing a refresh cycle of the IIC-Bus-programming, it is not useful to start a new AutoZero-action because no new source is selected and an undesired mute would appear at the outputs. For such applications the TDA7409 could be switched in the **AutoZero-Remain-Mode** (I2 bit of the subaddress-byte). If this bit is set to high, the DATABYTE 0 could be loaded without invoking the AutoZero and the old adjustment-value remains.

1.3 Mixing Stage

The 4 step Mixing stage offers the possibility to mix the rear selector signal or the phone signal to any other source. Due to the fact that the mixing-stage is located behind the In-Gain-stage fine adjustments of the main source level could be done in this way.

Figure 2. Signal-Flow of Mixing-Stage



1.4 Loudness

There are four parameters programmable in the loudness stage:

1.4.1 Attenuation

Figure 3 shows the attenuation as a function of frequency at $f_C = 400\text{Hz}$.

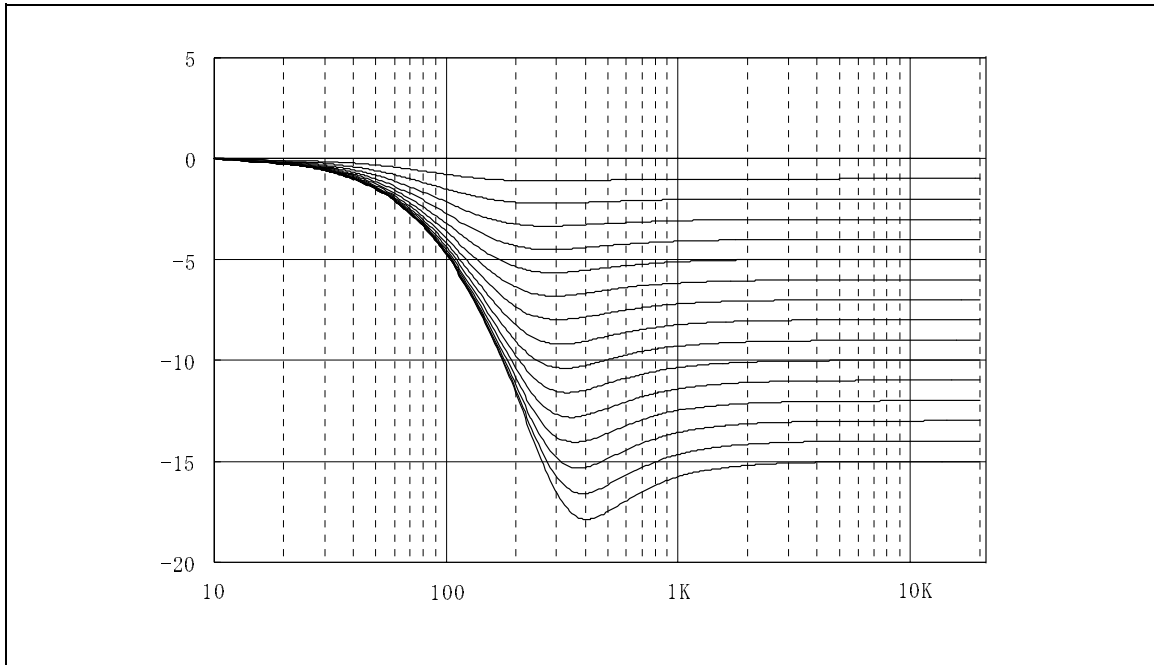
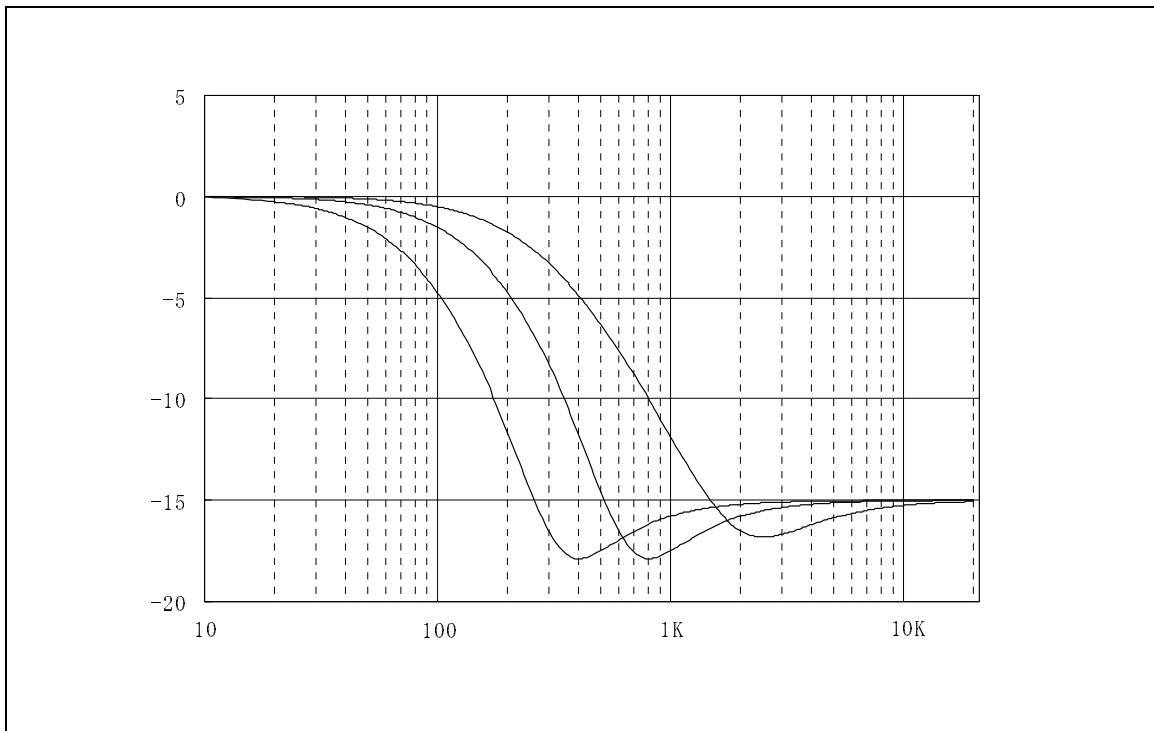
Figure 3. Loudness Attenuation @ $f_c = 400\text{Hz}$ **1.4.2 Center Frequency**

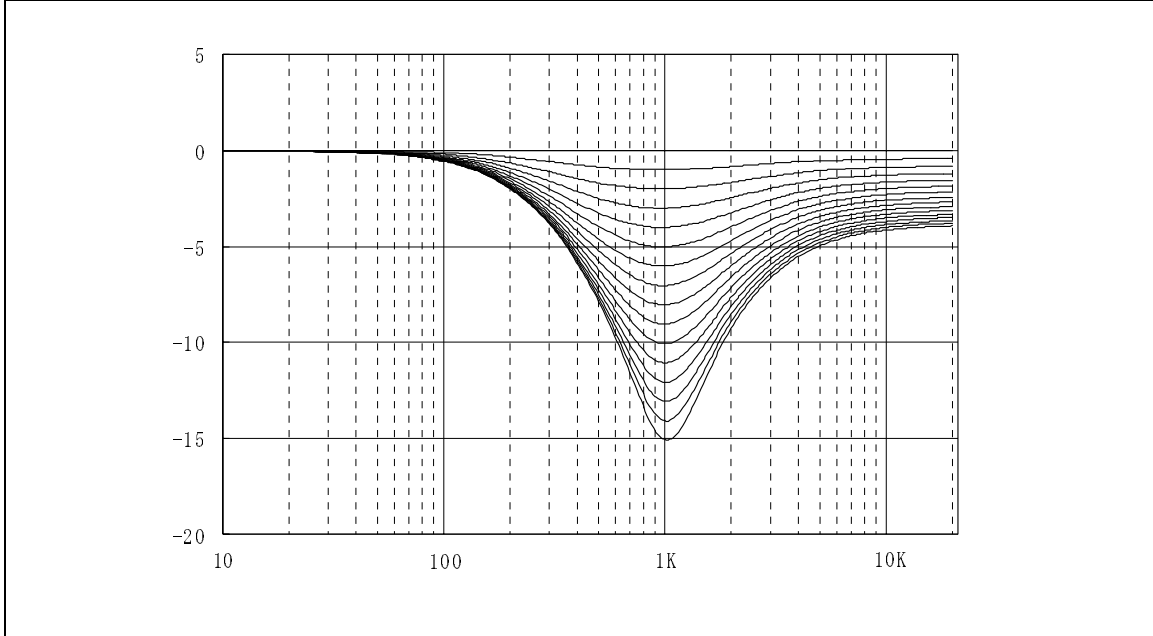
Figure 4 shows the three possible peak-frequencies 400Hz , 800Hz and 2.4kHz.

Figure 4. Loudness Center frequencies @ Attn. = 15dB

1.4.3 Low & High Frequency Boost

Figure 5 shows the different Loudness-shapes in low & high frequency boost.

Figure 5. Loudness Attenuation , $f_C = 2.4\text{KHz}$

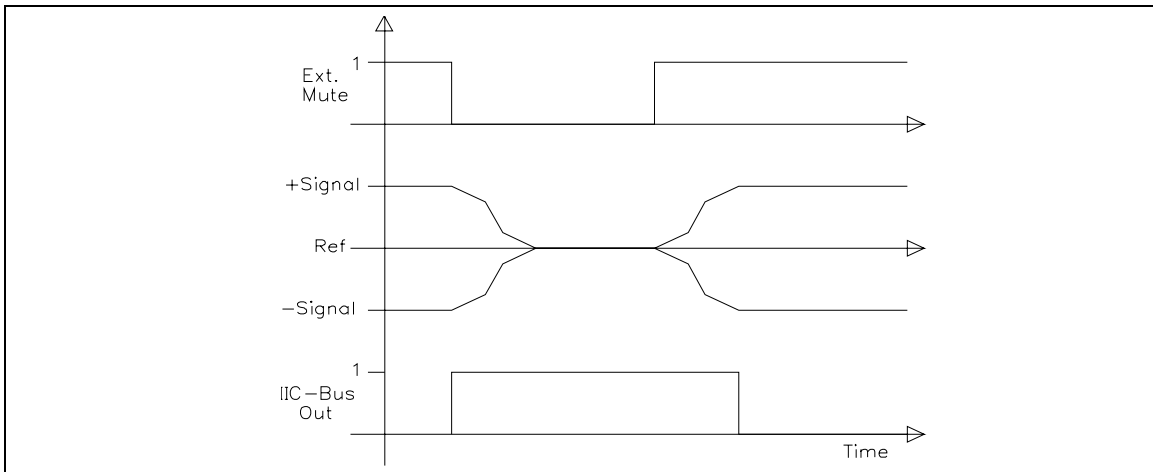


1.5 SoftMute

The digitally controlled SoftMute stage allows muting/demuting the signal with a I2C-bus programmable slope. The mute process can either be activated by the Mute pin or by the I2C-bus. This slope is realized in a special S-shaped curve to mute slow in the critical regions (see Figure 6).

For timing purposes the Bit 0 of the I2C-bus output register is set to 1 from the start of muting until the end of de-muting.

Figure 6. Softmute-Timing

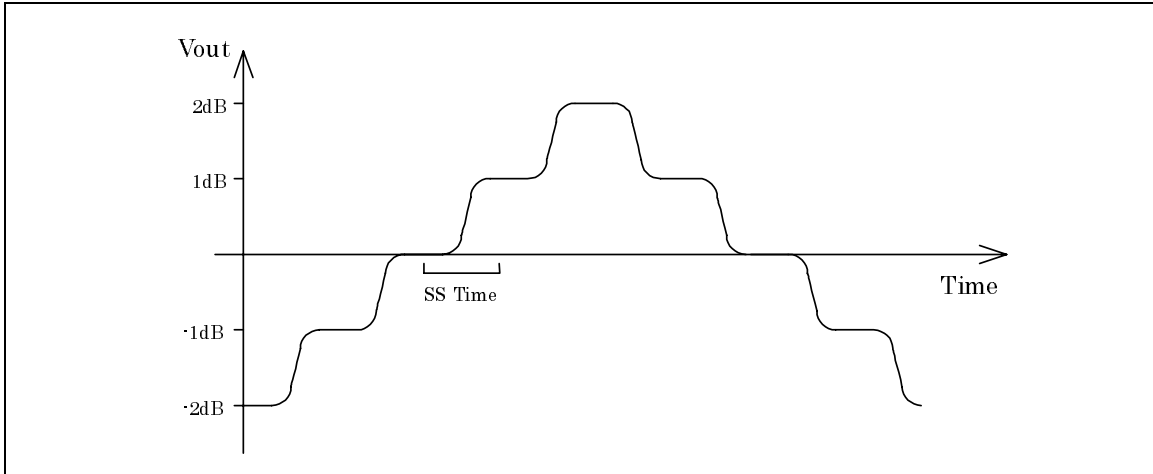


Note: Please notice that a started Mute-action is always terminated and could not be interrupted by a change of the mute -signal.

1.6 SoftStep-Volume

When the volume-level is changed audible clicks could appear at the output. The root cause of those clicks could either be a DC-Offset before the volume-stage or the sudden change of the envelope of the audiosignal. With the SoftStep-feature both kinds of clicks could be reduced to a minimum and are no more audible. Four programmable soft step time from one step to the next, are user selectable.

Figure 7. SoftStep-Timing



Note: For steps more than 1dB the SoftStep mode should be deactivated because it could generate a 1dB error during the blend-time.

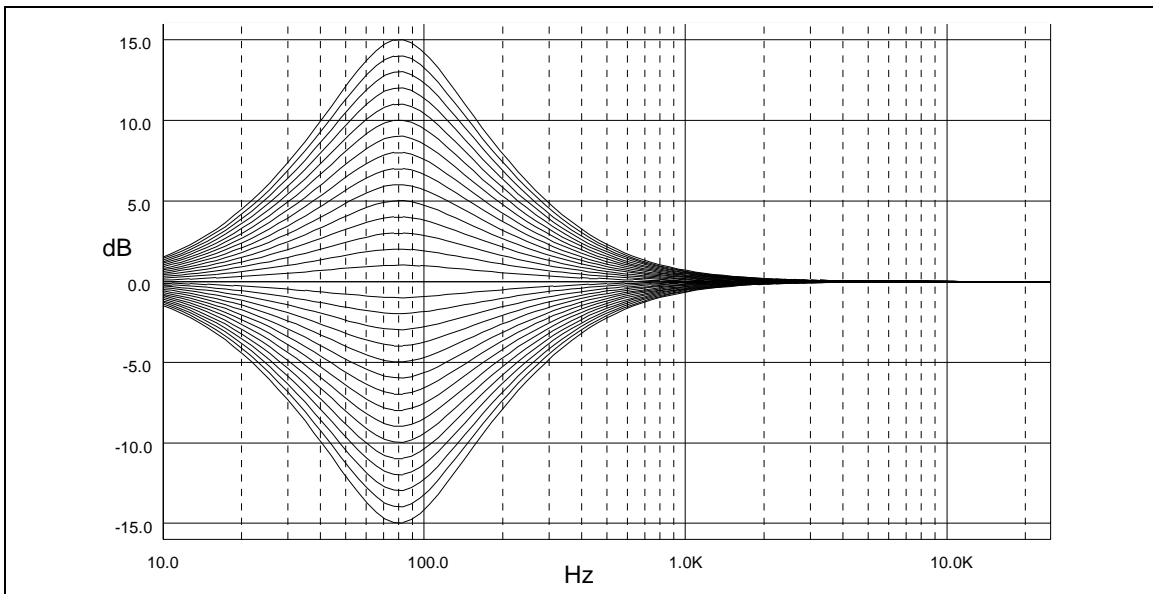
1.7 Bass

There are three parameters programmable in the bass stage:

1.7.1 Attenuation

Figure 8 shows the attenuation as a function of frequency at a center frequency of 80Hz.

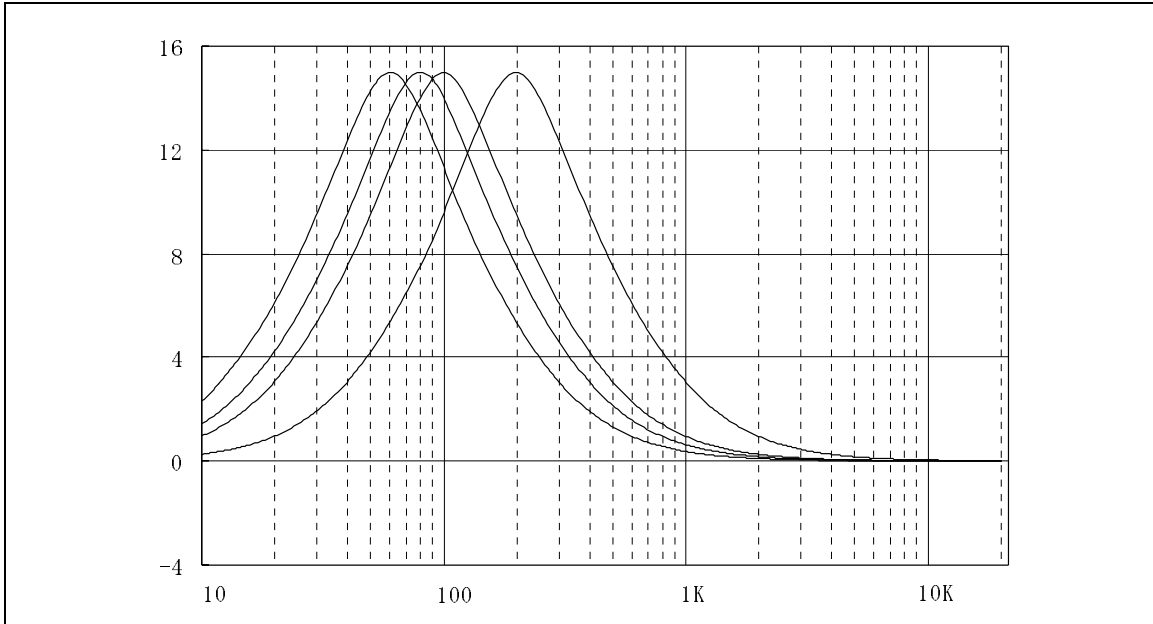
Figure 8. Bass Control @ $f_C = 80\text{Hz}$, $Q = 1$



1.7.2 Center Frequency

Figure 9 shows the four possible center frequencies 60, 80, 100 and 200Hz.

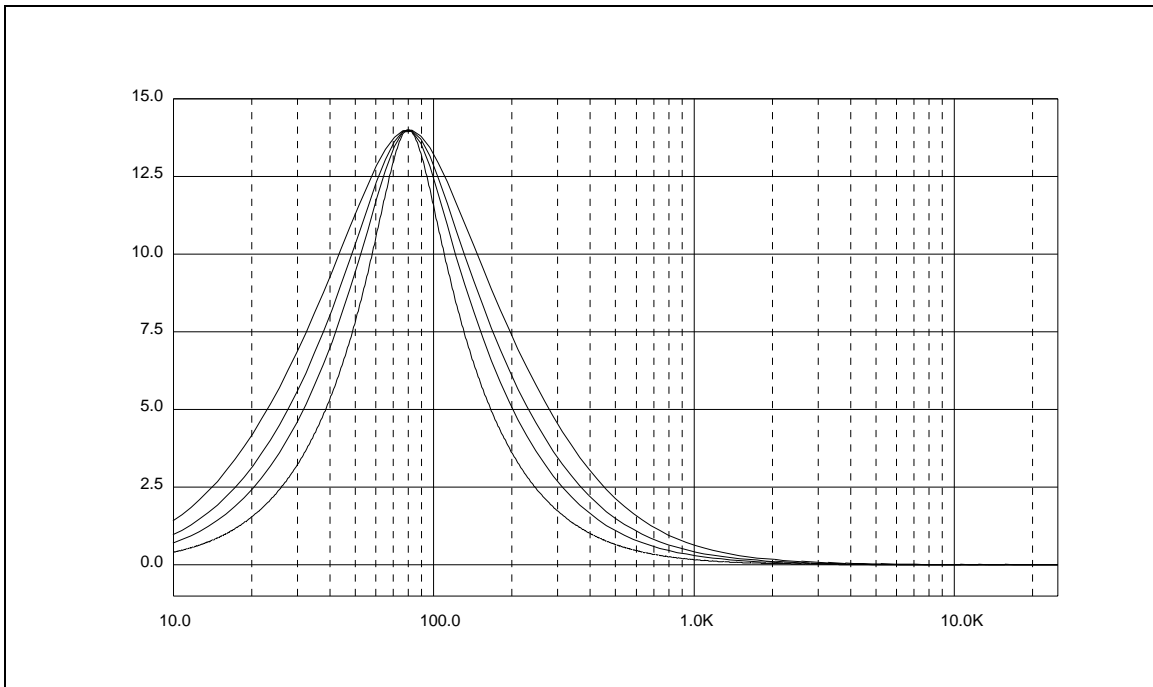
Figure 9. Bass center Frequencies @ Gain = 15dB, Q = 1



1.7.3 Quality Factors

Figure 10 shows the four possible quality factors 1, 1.25, 1.5 and 2.

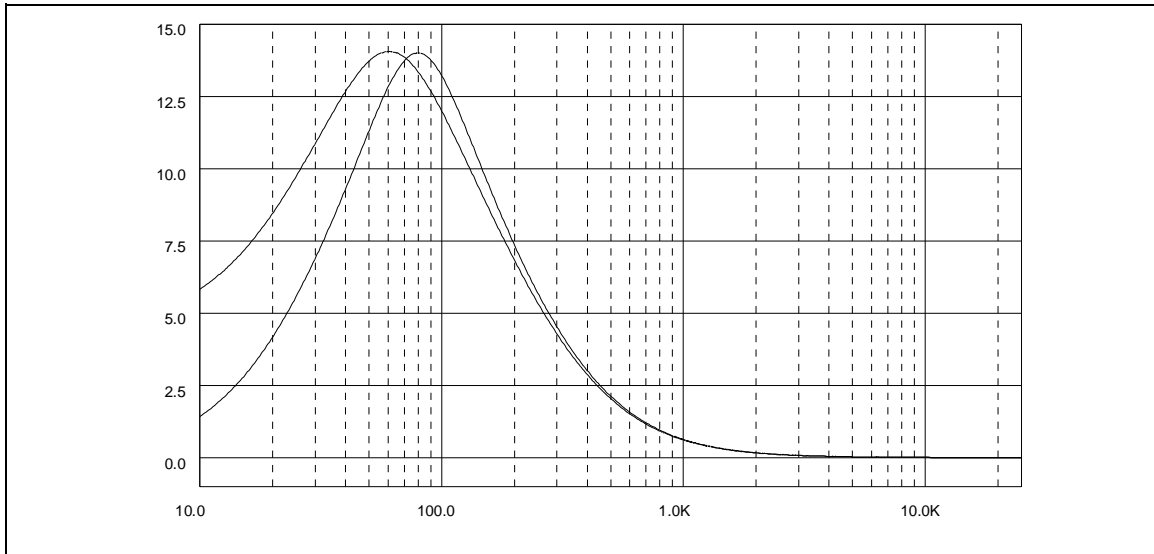
Figure 10. Bass Quality factors @ Gain = 14dB, fC = 80Hz



1.7.4 DC Mode

In this mode the DC-gain is increased by 4.4dB. In addition the programmed center frequency and quality factor is decreased by 25% which can be used to reach alternative center frequencies or quality factors.

Figure 11. Bass normal and DC Mode @ Gain = 14dB, $f_c = 80\text{Hz}$



Note: The center frequency, Q and DC-mode can be set fully independently.

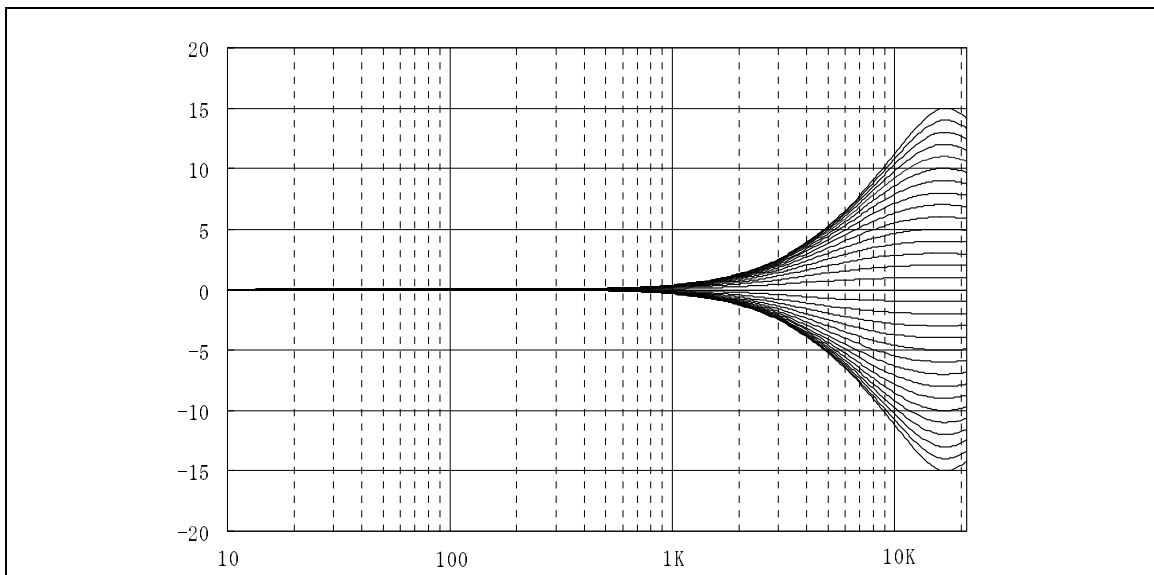
1.8 Treble

There are two parameters programmable in the treble stage:

1.8.1 Attenuation

Figure 12 shows the attenuation as a function of frequency at a center frequency of 17.5kHz.

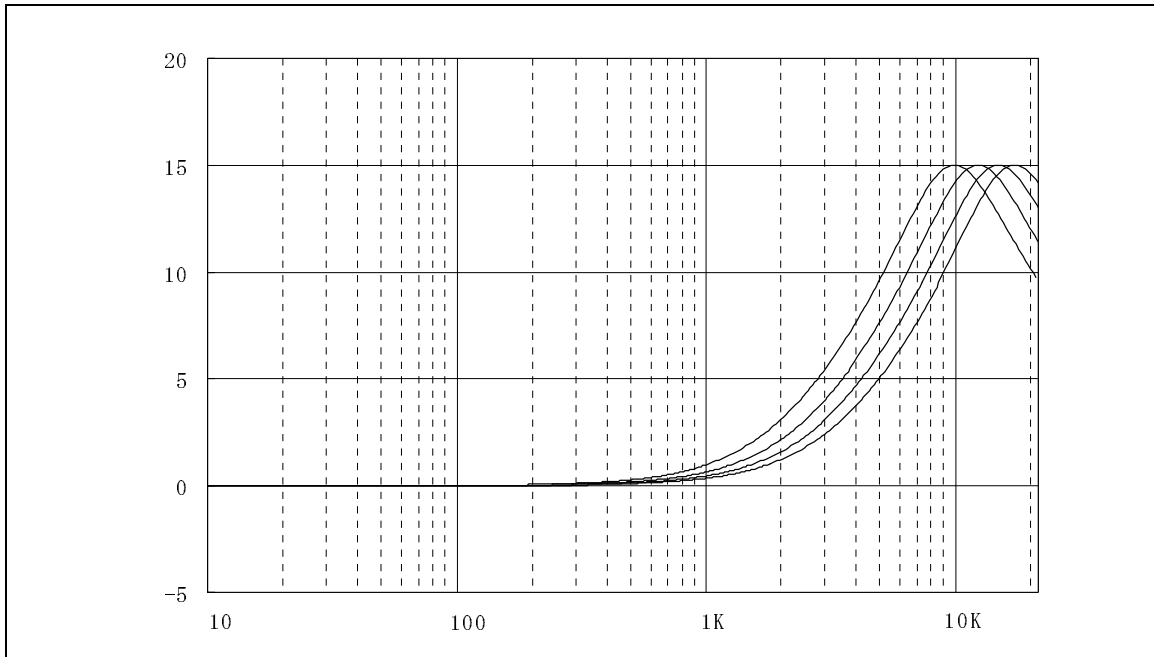
Figure 12. Treble Control @ $f_c = 17.5\text{kHz}$



1.8.2 Center Frequency

Figure 13 shows the four possible center frequencies 10k, 12.5k, 15k and 17.5kHz.

Figure 13. Treble Center Frequencies @ Gain = 15dB

**1.9 Speaker Attenuator**

Due to practical aspects the steps in the speaker-attenuators are not linear over the full range. At attenuations more than 24dB the steps increase from 1.5dB to 10dB (please see data byte specification).

1.10 Subwoofer Attenuator

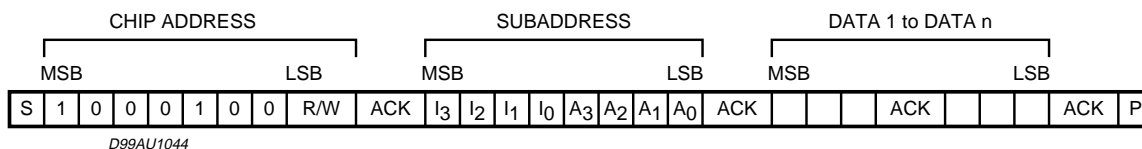
The Subwoofer output is a single ended stereo output. The attenuator is exactly the same like the other speakers.

2.0 I²C BUS INTERFACE

2.1 Interface Protocol

The interface protocol comprises:

- a start condition (S)
- a chip address byte (the LSB bit determines read / write transmission)
- a subaddress byte
- a sequence of data (N-bytes + acknowledge)
- a stop condition (P)
- the max. CLOCK SPEED is 500kbits/s



S = Start

R/W = "0" -> Receive-Mode (Chip could be programmed by P)

"1" -> Transmission-Mode (Data could be received by P)

ACK = Acknowledge

P = Stop

2.2 TRANSMITTED DATA (send mode)

| MSB | | | | | | | LSB |
|-----|---|---|---|---|---|---|-----|
| X | X | X | X | X | X | X | SM |

SM = Soft mute activated

X = Not Used

The transmitted data is automatic updated after each ACK. Transmission can be repeated without new chipaddress.

2.3 Reset Condition

A Power-On-Reset is invoked if the Supply-Voltage is below than 3.5V. After that the following data is written automatically into the registers of all subaddresses :

| MSB | | | | | | | LSB |
|-----|---|---|---|---|---|---|-----|
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

The programming after POR is marked bold-face / underlined in the programming tables.

With this programming all the outputs are muted to V_{REF} ($V_{OUT} = V_{DD}/2$).

Note : All the blank bits in the following tables are "don't care"-bits.

2.5 DATA BYTE SPECIFICATION

2.5.1 Input Selector / Gain

| MSB | | | | | | | LSB | | FUNCTION |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|------------------------|----------|
| D ₇ | D ₆ | D ₅ | D ₄ | D ₃ | D ₂ | D ₁ | D ₀ | | |
| | | | | | 0 | 0 | 0 | Source Selector | |
| | | | | | 0 | 0 | 1 | Not used | |
| | | | | | 0 | 1 | 0 | Single Ended 1 | |
| | | | | | 0 | 1 | 1 | Mute | |
| | | | | | 1 | 0 | 0 | Single Ended 2 | |
| | | | | | 1 | 0 | 1 | Single Ended 4 | |
| | | | | | 1 | 1 | 0 | Single Ended 3 | |
| | | | | | 1 | 1 | 1 | Mute | |
| | | | | | | | | Beep | |
| 0 | 0 | 0 | 0 | 0 | | | | Input Gain | |
| 0 | 0 | 0 | 0 | 1 | | | | 0dB | |
| 0 | 0 | 0 | 1 | 0 | | | | 1dB | |
| 0 | 0 | 0 | 1 | 1 | | | | 2dB | |
| 0 | 0 | 1 | 0 | 0 | | | | 3dB | |
| 0 | 0 | 1 | 0 | 1 | | | | 4dB | |
| 0 | 0 | 1 | 1 | 0 | | | | 5dB | |
| 0 | 0 | 1 | 1 | 1 | | | | 6dB | |
| 0 | 1 | 0 | 0 | 0 | | | | 7dB | |
| 0 | 1 | 0 | 0 | 1 | | | | 8dB | |
| 0 | 1 | 0 | 1 | 0 | | | | 9dB | |
| 0 | 1 | 0 | 1 | 1 | | | | 10dB | |
| 0 | 1 | 1 | 0 | 0 | | | | 11dB | |
| 0 | 1 | 1 | 0 | 1 | | | | 12dB | |
| 0 | 1 | 1 | 1 | 0 | | | | 13dB | |
| 0 | 1 | 1 | 1 | 1 | | | | 14dB | |
| 0 | 1 | 1 | 1 | 1 | | | | 16dB | |
| 1 | X | X | X | 0 | | | | 18dB | |
| 1 | X | X | X | 1 | | | | 20dB | |

2.5.2 Loudness

| MSB | | | | | | | LSB | | LOUDNESS |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------------------------|----------|
| D ₇ | D ₆ | D ₅ | D ₄ | D ₃ | D ₂ | D ₁ | D ₀ | | |
| | | | | 0 | 0 | 0 | 0 | Attenuation | |
| | | | | 0 | 0 | 0 | 1 | 0 dB | |
| | | | | : | : | : | : | -1 dB | |
| | | | | 1 | 1 | 1 | 0 | : | |
| | | | | 1 | 1 | 1 | 1 | -14 dB | |
| | | | | | | | | -15 dB | |
| | 0 | 0 | 0 | | | | | Filter / Center Frequency | |
| | | 0 | 1 | | | | | off(flat) 'D6 must be = 0' | |
| | | 1 | 0 | | | | | 400Hz | |
| | | 1 | 1 | | | | | 800Hz | |
| | | | | | | | | 2.4KHz | |
| | 0 | | | | | | | Shape | |
| | 1 | | | | | | | Low Boost | |
| | | | | | | | | Low & High Boost | |
| 0 | | | | | | | | SoftStep-Volume | |
| 1 | | | | | | | | off | |
| | | | | | | | | on | |

Note 1: The attenuation is specified at high frequencies. Around the center frequency the value is different depending on the programmed attenuation (see Loudness-frequency-response).

2.5.3 Volume

| MSB | | | | | | | LSB | | ATTENUATION |
|-----|----|----|----|----|----|----|-----|------------------|-------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Gain/Attenuation | |
| | 0 | 0 | 0 | 0 | 0 | 0 | 1 | not allow | |
| | 0 | 0 | 0 | 0 | 0 | 1 | 0 | not allow | |
| | 0 | 0 | 0 | 0 | 0 | 1 | 1 | +30.0dB | |
| | | | | | | | | +29.0dB | |
| | | | | | | | | : | |
| | 0 | 0 | 1 | 1 | 1 | 1 | 1 | +1.0dB | |
| | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.0dB | |
| | 0 | 1 | 0 | 0 | 0 | 0 | 1 | - 1.0dB | |
| | 0 | 1 | 0 | 0 | 0 | 1 | 0 | - 2.0dB | |
| | | | | | | | | : | |
| | 1 | 1 | 0 | 1 | 1 | 1 | 0 | -78.0dB | |
| | 1 | 1 | 0 | 1 | 1 | 1 | 1 | -79.0dB | |
| | 1 | 1 | 1 | X | X | X | X | Mute | |
| 0 | | | | | | | | Must BE "0" | |

Note 2: It is not recommended to use a gain more than 20dB for system performance reason. In general, the max. gain should be limited by software to the maximum value, which is needed for the system.

2.5.4 Treble Programming

| MSB | | | | | | | LSB | | BASS & TREBLE PROGRAMMING |
|-----|----|----|----|----|----|----|-----|-------------------------|---------------------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| | | | | 0 | 0 | 0 | 0 | Treble Steps | |
| | | | | 0 | 0 | 0 | 1 | 15dB | |
| | | | | 0 | 0 | 1 | 0 | 14dB | |
| | | | | 0 | 0 | 1 | 1 | 13dB | |
| | | | | 0 | 1 | 0 | 0 | 12dB | |
| | | | | 0 | 1 | 0 | 1 | 11dB | |
| | | | | 0 | 1 | 1 | 0 | 10dB | |
| | | | | 0 | 1 | 1 | 1 | 9dB | |
| | | | | 1 | 0 | 0 | 0 | 8dB | |
| | | | | 1 | 0 | 0 | 1 | 7dB | |
| | | | | 1 | 0 | 1 | 0 | 6dB | |
| | | | | 1 | 0 | 1 | 1 | 5dB | |
| | | | | 1 | 1 | 0 | 0 | 4dB | |
| | | | | 1 | 1 | 0 | 1 | 3dB | |
| | | | | 1 | 1 | 0 | 1 | 2dB | |
| | | | | 1 | 1 | 1 | 0 | 1dB | |
| | | | | 1 | 1 | 1 | 1 | 0dB | |
| | | | 0 | | | | | Mode | |
| | | | 1 | | | | | Cut | |
| | | | | | | | | Boost | |
| X | 0 | 0 | | | | | | Treble Center Frequency | |
| X | 0 | 1 | | | | | | 10KHz | |
| X | 1 | 0 | | | | | | 12.5KHz | |
| X | 1 | 1 | | | | | | 15KHz | |
| | | | | | | | | 17.5KHz | |



2.5.5 Bass Programming

| MSB | | | | | | | LSB | BASS & TREBLE PROGRAMMING |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------------------|
| D ₇ | D ₆ | D ₅ | D ₄ | D ₃ | D ₂ | D ₁ | D ₀ | |
| | | | | 0 | 0 | 0 | 0 | Bass Steps 15dB |
| | | | | 0 | 0 | 0 | 1 | 14dB |
| | | | | 0 | 0 | 1 | 0 | 13dB |
| | | | | 0 | 0 | 1 | 1 | 12dB |
| | | | | 0 | 1 | 0 | 0 | 11dB |
| | | | | 0 | 1 | 0 | 1 | 10dB |
| | | | | 0 | 1 | 1 | 0 | 9dB |
| | | | | 0 | 1 | 1 | 1 | 8dB |
| | | | | 1 | 0 | 0 | 0 | 7dB |
| | | | | 1 | 0 | 0 | 1 | 6dB |
| | | | | 1 | 0 | 1 | 0 | 5dB |
| | | | | 1 | 0 | 1 | 1 | 4dB |
| | | | | 1 | 1 | 0 | 0 | 3dB |
| | | | | 1 | 1 | 0 | 1 | 2dB |
| | | | | 1 | 1 | 1 | 0 | 1dB |
| | | | | 1 | 1 | 1 | 1 | 0dB |
| | | | 0 | | | | | Mode Cut |
| | | | 1 | | | | | Boost |
| | 0 | 0 | | | | | | Quality Factor 1 |
| | 0 | 1 | | | | | | 1.25 |
| | 1 | 0 | | | | | | 1.5 |
| | 1 | 1 | | | | | | 2 |
| 0 | | | | | | | | DC - Mode Off |
| 1 | | | | | | | | On |

Note 3: For more information please refer to section Bass description

2.5.6 Speaker Attenuator Left Front

| MSB | | | | | | | LSB | ATTENUATION / BASS CF |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|--------------------------------------|
| D ₇ | D ₆ | D ₅ | D ₄ | D ₃ | D ₂ | D ₁ | D ₀ | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | Attenuation 0 dB |
| | | 0 | 0 | 0 | 0 | 0 | 1 | -1 dB |
| | | : | : | : | : | : | : | : |
| | | 0 | 1 | 0 | 1 | 1 | 1 | -23 dB |
| | | 0 | 1 | 1 | 0 | 0 | 0 | -24.5dB |
| | | 0 | 1 | 1 | 0 | 0 | 1 | -26 dB |
| | | 0 | 1 | 1 | 0 | 1 | 0 | -28 dB |
| | | 0 | 1 | 1 | 0 | 1 | 1 | -30 dB |
| | | 0 | 1 | 1 | 1 | 0 | 0 | -32 dB |
| | | 0 | 1 | 1 | 1 | 0 | 1 | -35 dB |
| | | 0 | 1 | 1 | 1 | 1 | 0 | -40 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | -50 dB |
| | | 1 | X | X | X | X | X | Speaker Mute |
| 0 | 0 | | | | | | | Bass Center-Frequency 60Hz |
| 0 | 1 | | | | | | | 80Hz |
| 1 | 0 | | | | | | | 100Hz |
| 1 | 1 | | | | | | | 200Hz |

2.5.7 Speaker Attenuator Right Front

| MSB | | | | | | | LSB | | ATTENUATION |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---|---------------------|
| D ₇ | D ₆ | D ₅ | D ₄ | D ₃ | D ₂ | D ₁ | D ₀ | | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Attenuation 0 dB |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | -1 dB |
| | | : | : | : | : | : | : | : | : |
| | | 0 | 1 | 0 | 1 | 1 | 1 | 1 | -23 dB |
| | | 0 | 1 | 1 | 0 | 0 | 0 | 0 | -24.5dB |
| | | 0 | 1 | 1 | 0 | 0 | 1 | 1 | -26 dB |
| | | 0 | 1 | 1 | 0 | 1 | 0 | 0 | -28 dB |
| | | 0 | 1 | 1 | 0 | 1 | 1 | 1 | -30 dB |
| | | 0 | 1 | 1 | 1 | 1 | 0 | 0 | -32 dB |
| | | 0 | 1 | 1 | 1 | 0 | 1 | 1 | -35 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 0 | -40 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 1 | -50 dB |
| X | X | 1 | X | X | X | X | X | X | Speaker Mute |

2.5.8 Speaker Attenuator Left Rear

| MSB | | | | | | | LSB | | ATTENUATION / Soft Step Time |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---|------------------------------|
| D ₇ | D ₆ | D ₅ | D ₄ | D ₃ | D ₂ | D ₁ | D ₀ | | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Attenuation 0 dB |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | -1 dB |
| | | : | : | : | : | : | : | : | : |
| | | 0 | 1 | 0 | 1 | 1 | 1 | 1 | -23 dB |
| | | 0 | 1 | 1 | 0 | 0 | 0 | 0 | -24.5dB |
| | | 0 | 1 | 1 | 0 | 0 | 1 | 1 | -26 dB |
| | | 0 | 1 | 1 | 0 | 1 | 0 | 0 | -28 dB |
| | | 0 | 1 | 1 | 0 | 1 | 1 | 1 | -30 dB |
| | | 0 | 1 | 1 | 1 | 1 | 0 | 0 | -32 dB |
| | | 0 | 1 | 1 | 1 | 0 | 1 | 1 | -35 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 0 | -40 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 1 | -50 dB |
| X | X | 1 | X | X | X | X | X | X | Speaker Mute |

2.5.9 Speaker Attenuator Right Rear

| MSB | | | | | | | LSB | | ATTENUATION |
|-----|----|----|----|----|----|----|-----|---|--------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Attenuation |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 dB |
| | | : | : | : | : | : | : | : | -1 dB |
| | | 0 | 1 | 0 | 1 | 1 | 1 | 1 | -23 dB |
| | | 0 | 1 | 1 | 0 | 0 | 0 | 0 | -24.5dB |
| | | 0 | 1 | 1 | 0 | 0 | 1 | 1 | -26 dB |
| | | 0 | 1 | 1 | 0 | 1 | 0 | 0 | -28 dB |
| | | 0 | 1 | 1 | 0 | 1 | 1 | 1 | -30 dB |
| | | 0 | 1 | 1 | 1 | 1 | 0 | 0 | -32 dB |
| | | 0 | 1 | 1 | 1 | 0 | 1 | 1 | -35 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 0 | -40 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 1 | -50 dB |
| X | X | 1 | X | X | X | X | X | X | Speaker Mute |

2.5.10 Subwoofer Attenuator (Left & Right)

| MSB | | | | | | | LSB | | FUNCTION |
|-----|----|----|----|----|----|----|-----|---|--------------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Attenuation |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 dB |
| | | : | : | : | : | : | : | : | -1 dB |
| | | 0 | 1 | 0 | 1 | 1 | 1 | 1 | -23 dB |
| | | 0 | 1 | 1 | 0 | 0 | 0 | 0 | -24.5dB |
| | | 0 | 1 | 1 | 0 | 0 | 1 | 1 | -26 dB |
| | | 0 | 1 | 1 | 0 | 1 | 0 | 0 | -28 dB |
| | | 0 | 1 | 1 | 0 | 1 | 1 | 1 | -30 dB |
| | | 0 | 1 | 1 | 1 | 1 | 0 | 0 | -32 dB |
| | | 0 | 1 | 1 | 1 | 0 | 1 | 1 | -35 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 0 | -40 dB |
| | | 0 | 1 | 1 | 1 | 1 | 1 | 1 | -50 dB |
| X | X | 1 | X | X | X | X | X | X | Speaker Mute |

2.5.11 SoftMute and Mixing

| MSB | | | | | | | LSB | | FUNCTION |
|------------------|------------------|------------------|------------------|----|------------------|------------------|-----|--------|---|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| | | | | | | | | 0 1 | Mute enable SoftMute disable SoftMute |
| | | | | | 0 0 1 1 | 0 1 0 1 | | | Mute/Zero Cross-Times 0.48ms 0.96ms 30.7ms / 9ms 122.8ms / 37ms |
| | | | | 0 | | | | | Must BE "0" |
| | | 0 0 1 1 | 0 1 0 1 | | | | | | Mixing-Level (Main / Mix-Source) -12 / -2.5dB -6 / -6dB -3.5 / -9.6dB 0 / ∞ |
| 0 0 1 1 | 0 1 0 1 | | | | | | | | Beep Frequency 781Hz 1.56KHz Not allow 1.8KHz |

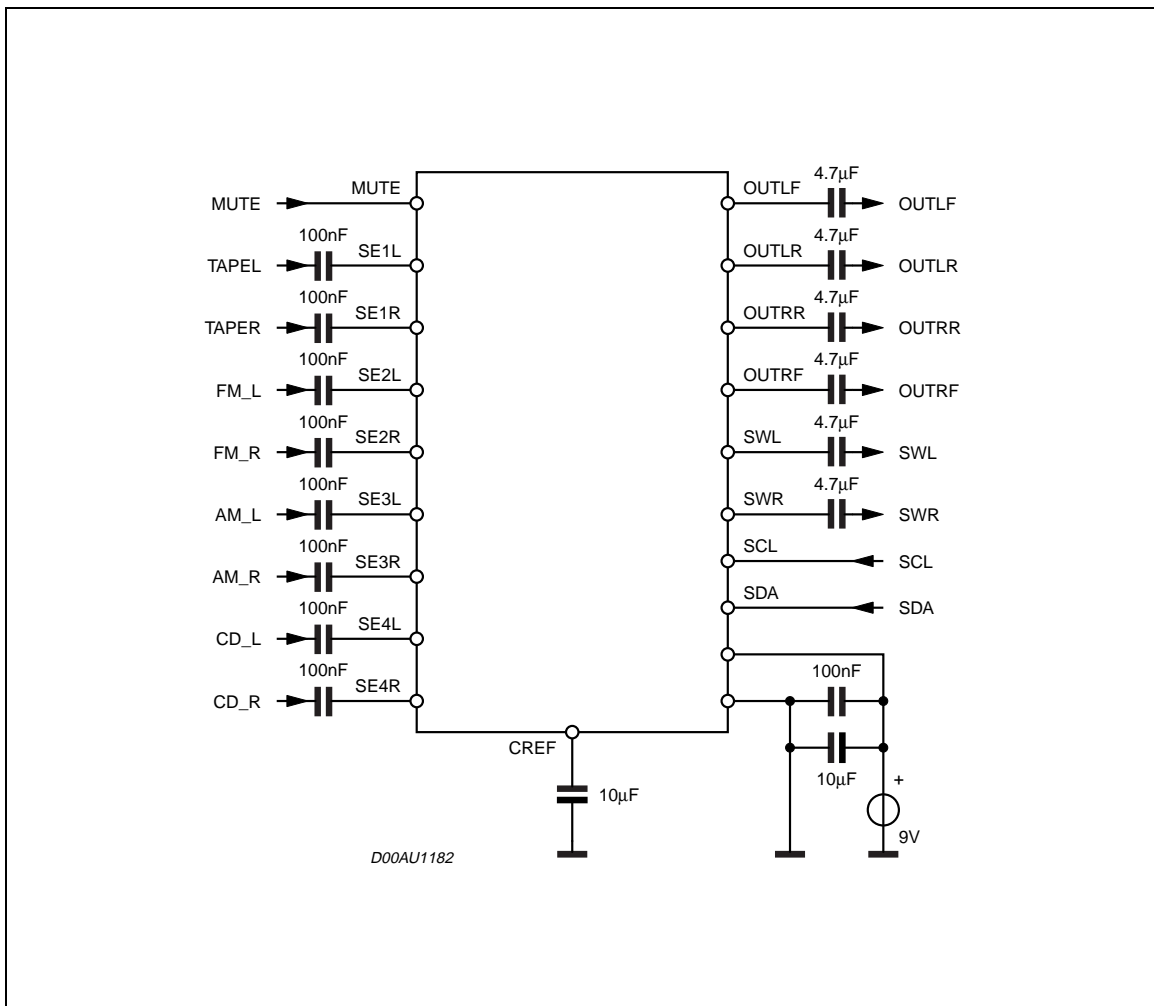
2.5.12 Others

| MSB | | | | | | | LSB | | FUNCTION |
|--------|----|------------------|------------------|----|----|----|-----|--|----------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| | | | | | | X | 0 | AC-Coupling Internal pass | |
| | | | | 1 | 1 | | | Must be "1" Must be "1" | |
| | | 0 0 1 1 | 0 1 0 1 | | | | | Soft Step Time 0.68ms 1.26ms 2.52ms 5.04ms | |
| | 1 | | | | | | | Must be "1" for Auto zero | |
| 0 1 | | | | | | | | Internal Beep Off ON | |

2.5.13 Testing

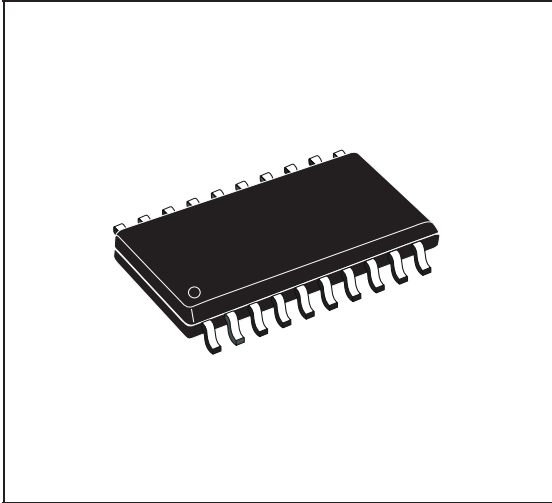
| MSB | | | | | | | LSB | | Testing |
|-----|----|--------|--------|--------|--------|--------|--------|---|---------|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | |
| | | X X | X X | X X | | | 0 1 | Main-Testmode off on | |
| | | X X | X X | X X | | 0 1 | | Test-Multiplexer internal 200kHz Clock internal Bandgap Voltage | |
| | | X X | X X | X X | 0 1 | | | Clock external internal | |
| 1 | 1 | | | | | | | must be "1" | |

Figure 14. TDA7409 Application Circuit

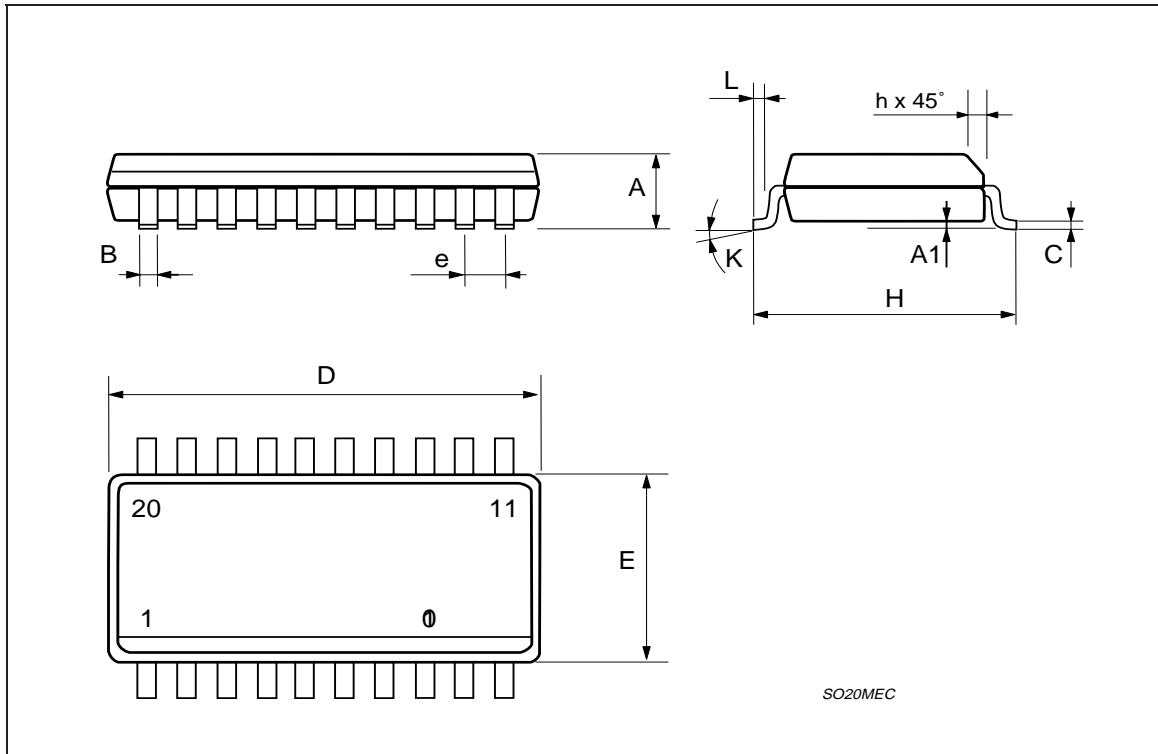


| DIM. | mm | | | inch | | |
|------|--------------------|------|-------|-------|-------|-------|
| | MIN. | TYP. | MAX. | MIN. | TYP. | MAX. |
| A | 2.35 | | 2.65 | 0.093 | | 0.104 |
| A1 | 0.1 | | 0.3 | 0.004 | | 0.012 |
| B | 0.33 | | 0.51 | 0.013 | | 0.020 |
| C | 0.23 | | 0.32 | 0.009 | | 0.013 |
| D | 12.6 | | 13 | 0.496 | | 0.512 |
| E | 7.4 | | 7.6 | 0.291 | | 0.299 |
| e | | 1.27 | | | 0.050 | |
| H | 10 | | 10.65 | 0.394 | | 0.419 |
| h | 0.25 | | 0.75 | 0.010 | | 0.030 |
| L | 0.4 | | 1.27 | 0.016 | | 0.050 |
| K | 0° (min.)8° (max.) | | | | | |

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