# STEREO-TONE/VOLUME CONTROL CIRCUIT

## GENERAL DESCRIPTION

The device is designed as an active stereo-tone/volume control for car radios, TV receivers and mains-fed equipment. It includes functions for bass and treble control, volume control with built-in contour (can be switched off) and balance. All these functions can be controlled by d.c. voltages or by single linear potentiometers.

### Features

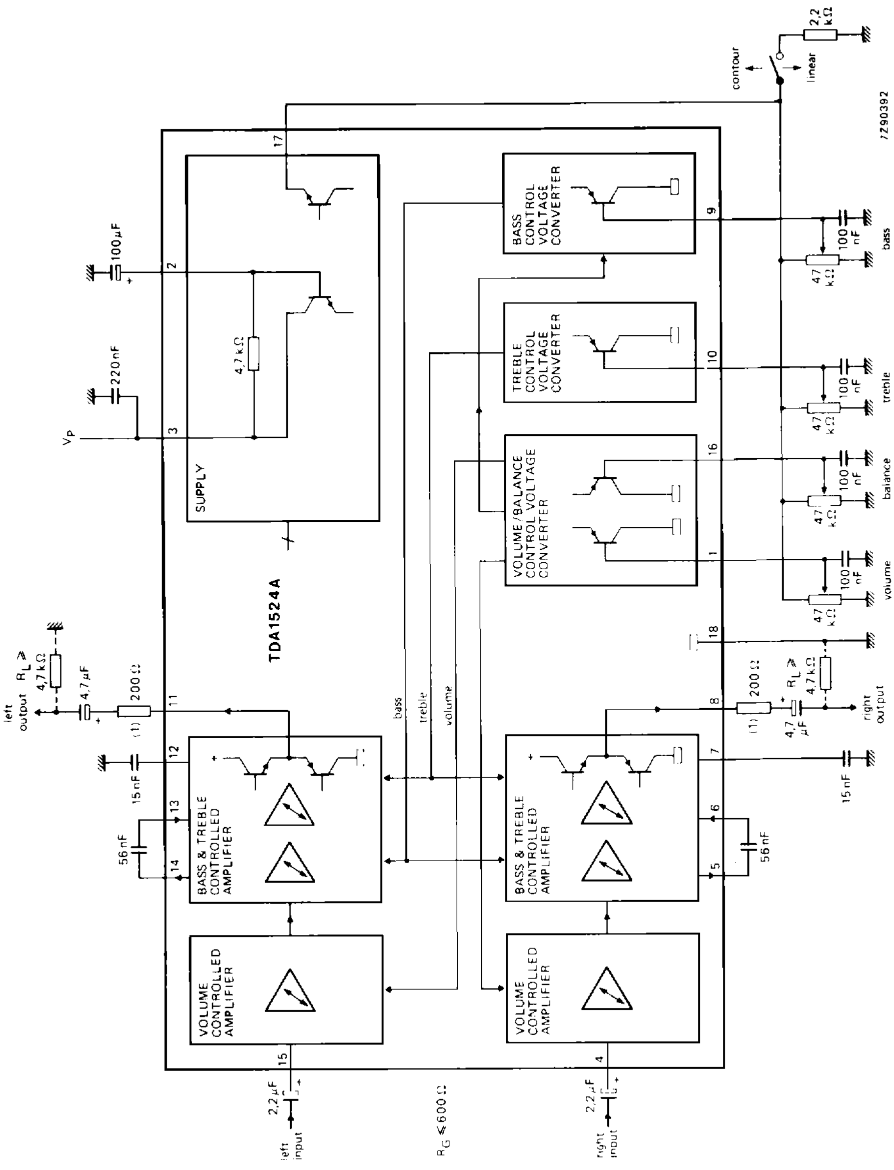
- Few external components necessary
- Low noise due to internal gain
- Bass emphasis can be increased by a double-pole low-pass filter
- Wide power supply voltage range

## QUICK REFERENCE DATA

| | | | | |
|---|---|---|---|---|
| Supply voltage (pin 3) | $V_P = V_{3\text{-}18}$ | typ. | 12 | V |
| Supply current (pin 3) | $I_P = I_3$ | typ. | 35 | mA |
| Maximum input signal with d.c. feedback (r.m.s. value) | $V_{i(rms)}$ | typ. | 2,5 | V |
| Maximum output signal with d.c. feedback (r.m.s. value) | $V_{o(rms)}$ | typ. | 3 | V |
| Volume control range | $G_v$ | | −80 to + 21,5 | dB |
| Bass control range at 40 Hz | $\Delta G_v$ | | −19 to + 17 | dB |
| Treble control range at 16 kHz | $\Delta G_v$ | typ. | ± 15 | dB |
| Total harmonic distortion | THD | typ. | 0,3 | % |
| Output noise voltage (unweighted; r.m.s. value) at f = 20 Hz to 20 kHz; $V_P$ = 12 V; | | | | |
| for max. voltage gain | $V_{no(rms)}$ | typ. | 310 | μV |
| for voltage gain $G_v$ = −40 dB | $V_{no(rms)}$ | typ. | 100 | μV |
| Channel separation at $G_v$ = −20 to + 21,5 dB | $\alpha_{cs}$ | typ. | 60 | dB |
| Tracking between channels at $G_v$ = −20 to + 26 dB | $\Delta G_v$ | max. | 2,5 | dB |
| Ripple rejection at 100 Hz | RR | typ. | 50 | dB |
| Supply voltage range (pin 3) | $V_P = V_{3\text{-}18}$ | | 7,5 to 16,5 | V |
| Operating ambient temperature range | $T_{amb}$ | | −30 to + 80 | °C |

## PACKAGE OUTLINE

18-lead DIL; plastic (SOT102).




(1) Series resistor is recommended in the event of the capacitive loads exceeding 200 pF.

Fig. 1 Block diagram and application circuit with single-pole filter.

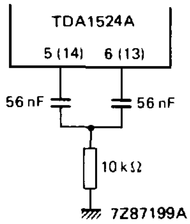



Fig. 2 Double-pole low-pass filter for improved bass-boost.

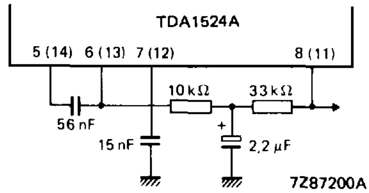



Fig. 3 D.C. feedback with filter network for improved signal handling.

## RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

| | | | | |
|---|---|---|---|---|
| Supply voltage (pin 3) | $V_P = V_{3\text{-}18}$ | max. | 20 | V |
| Total power dissipation | $P_{tot}$ | max. | 1200 | mW |
| Storage temperature range | $T_{stg}$ | −55 to + 150 | | °C |
| Operating ambient temperature range | $T_{amb}$ | −30 to + 80 | | °C |

## D.C. CHARACTERISTICS

$V_P = V_{3\text{-}18} = 12$ V; $T_{amb} = 25$ °C; measured in Fig. 1; $R_G \leqslant 600\ \Omega$; $R_L \geqslant 4,7$ kΩ; $C_L \leqslant 200$ pF; unless otherwise specified

| parameter | symbol | min. | typ. | max. | unit |
|---|---|---|---|---|---|
| **Supply** (pin 3) | | | | | |
| Supply voltage | $V_P = V_{3\text{-}18}$ | 7,5 | – | 16,5 | V |
| Supply current | | | | | |
| at $V_P = 8,5$ V | $I_P = I_3$ | 19 | 27 | 35 | mA |
| at $V_P = 12$ V | $I_P = I_3$ | 25 | 35 | 45 | mA |
| at $V_P = 15$ V | $I_P = I_3$ | 30 | 43 | 56 | mA |
| D.C. input levels (pins 4 and 15) | | | | | |
| at $V_P = 8,5$ V | $V_{4,15\text{-}18}$ | 3,8 | 4,25 | 4,7 | V |
| at $V_P = 12$ V | $V_{4,15\text{-}18}$ | 5,3 | 5,9 | 6,6 | V |
| at $V_P = 15$ V | $V_{4,15\text{-}18}$ | 6,5 | 7,3 | 8,2 | V |
| D.C. output levels (pins 8 and 11) under all control voltage conditions with d.c. feedback (Fig. 3) | | | | | |
| at $V_P = 8,5$ V | $V_{8,11\text{-}18}$ | 3,3 | 4,25 | 5,2 | V |
| at $V_P = 12$ V | $V_{8,11\text{-}18}$ | 4,6 | 6,0 | 7,4 | V |
| at $V_P = 15$ V | $V_{8,11\text{-}18}$ | 5,7 | 7,5 | 9,3 | V |
| **Pin 17** | | | | | |
| Internal potentiometer supply voltage at $V_P = 8,5$ V | $V_{17\text{-}18}$ | 3,5 | 3,75 | 4,0 | V |
| Contour on/off switch (control by $I_{17}$) | | | | | |
| contour (switch open) | $-I_{17}$ | – | – | 0,5 | mA |
| linear (switch closed) | $-I_{17}$ | 1,5 | – | 10 | mA |
| Application without internal potentiometer supply voltage at $V_P \geqslant 10,8$ V (contour cannot be switched off) | | | | | |
| Voltage range forced to pin 17 | $V_{17\text{-}18}$ | 4,5 | – | $V_P/2 - V_{BE}$ | V |
| D.C. control voltage range for volume, bass, treble and balance (pins 1, 9, 10 and 16 respectively) | | | | | |
| at $V_{17\text{-}18} = 5$ V | $V_{1,9,10,16}$ | 1,0 | – | 4,25 | V |
| using internal supply | $V_{1,9,10,16}$ | 0,25 | – | 3,8 | V |
| Input current of control inputs (pins 1, 9, 10 and 16) | $-I_{1,9,10,16}$ | – | – | 5 | μA |

## A.C. CHARACTERISTICS

$V_P = V_{3\text{-}18} = 8{,}5$ V; $T_{amb} = 25$ °C; measured in Fig. 1; contour switch closed (linear position); volume, balance, bass, and treble controls in mid-position; $R_G \leqslant 600\ \Omega$; $R_L \geqslant 4{,}7$ kΩ; $C_L \leqslant 200$ pF; f = 1 kHz; unless otherwise specified

| parameter | symbol | min. | typ. | max. | unit |
|---|---|---|---|---|---|
| **Control range** | | | | | |
| Max. gain of volume (Fig. 5) | $G_{v\ max}$ | 20,5 | 21,5 | 23 | dB |
| Volume control range; $G_{v\ max}/G_{v\ min}$ | $\Delta G_v$ | 90 | 100 | – | dB |
| Balance control range; $G_v = 0$ dB (Fig. 6) | $\Delta G_v$ | – | –40 | – | dB |
| Bass control range at 40 Hz (Fig. 7) | $\Delta G_v$ | – | –19 to + 17 ± 3 | | dB |
| Treble control range at 16 kHz (Fig. 8) | $\Delta G_v$ | – | ± 15 ± 3 | – | dB |
| Contour characteristics | | see Figs 9 and 10 | | | |
| **Signal inputs, outputs** | | | | | |
| Input resistance; pins 4 and 15 (note 1) | | | | | |
| at gain of volume control: $G_v = 20$ dB | $R_{i4,15}$ | 10 | – | – | kΩ |
| $G_v = -40$ dB | $R_{i4,15}$ | – | 160 | – | kΩ |
| Output resistance (pins 8 and 11) | $R_{o8,11}$ | – | – | 300 | Ω |
| **Signal processing** | | | | | |
| Power supply ripple rejection at $V_{P(rms)} \leqslant 200$ mV; f = 100 Hz; $G_v = 0$ dB | RR | 35 | 50 | – | dB |
| Channel separation (250 Hz to 10 kHz) at $G_v = -20$ to + 21,5 dB | $\alpha_{cs}$ | 46 | 60 | – | dB |
| Spread of volume control with constant control voltage $V_{1\text{-}18} = 0{,}5\ V_{17\text{-}18}$ | $\Delta G_v$ | – | – | ± 3 | dB |
| Gain tolerance between left and right channel $V_{16\text{-}18} = V_{1\text{-}18} = 0{,}5\ V_{17\text{-}18}$ | $\Delta G_{v,L\text{-}R}$ | – | – | 1,5 | dB |
| Tracking between channels for $G_v = 21{,}5$ to $-26$ dB f = 250 Hz to 6,3 kHz; balance adjusted at $G_v = 10$ dB | $\Delta G_v$ | – | – | 2,5 | dB |

A.C. CHARACTERISTICS (continued)

| parameter | symbol | min. | typ. | max. | unit |
|---|---|---|---|---|---|
| **Signal handling with d.c. feedback** (Fig. 3) | | | | | |
| Input signal handling | | | | | |
| at $V_P$ = 8,5 V; THD = 0,5%; f = 1 kHz (r.m.s. value) | $V_{i(rms)}$ | 1,4 | – | – | V |
| at $V_P$ = 8,5 V; THD = 0,7%; f = 1 kHz (r.m.s. value) | $V_{i(rms)}$ | 1,8 | 2,4 | – | V |
| at $V_P$ = 12 V; THD = 0,5%; f = 40 Hz to 16 kHz (r.m.s. value) | $V_{i(rms)}$ | 1,4 | – | – | V |
| at $V_P$ = 12 V; THD = 0,7%; f = 40 Hz to 16 kHz (r.m.s. value) | $V_{i(rms)}$ | 2,0 | 3,2 | – | V |
| at $V_P$ = 15 V; THD = 0,5%; f = 40 Hz to 16 kHz (r.m.s. value) | $V_{i(rms)}$ | 1,4 | – | – | V |
| at $V_P$ = 15 V; THD = 0,7%; f = 40 Hz to 16 kHz (r.m.s. value) | $V_{i(rms)}$ | 2,0 | 3,2 | – | V |
| Output signal handling (note 2 and note 3) | | | | | |
| at $V_P$ = 8,5 V; THD = 0,5%; f = 1 kHz (r.m.s. value) | $V_{o(rms)}$ | 1,8 | 2,0 | – | V |
| at $V_P$ = 8,5 V; THD = 10%; f = 1 kHz (r.m.s. value) | $V_{o(rms)}$ | – | 2,2 | – | V |
| at $V_P$ = 12 V; THD = 0,5%; f = 40 Hz to 16 kHz (r.m.s. value) | $V_{o(rms)}$ | 2,5 | 3,0 | – | V |
| at $V_P$ = 15 V; THD = 0,5%; f = 40 Hz to 16 kHz (r.m.s. value) | $V_{o(rms)}$ | – | 3,5 | – | V |
| **Noise performance** ($V_P$ = 8,5 V) | | | | | |
| Output noise voltage (unweighted; Fig. 15) at f = 20 Hz to 20 kHz (r.m.s. value) | | | | | |
| for maximum voltage gain (note 4) | $V_{no(rms)}$ | – | 260 | – | µV |
| for $G_v$ = −3 dB (note 4) | $V_{no(rms)}$ | – | 70 | 140 | µV |
| Output noise voltage; weighted as DIN 45405 of 1981, CCIR recommendation 468-2 (peak value) | | | | | |
| for maximum voltage gain (note 4) | $V_{no(m)}$ | – | 890 | – | µV |
| for maximum emphasis of bass and treble (contour off; $G_v$ = −40 dB) | $V_{no(m)}$ | – | 360 | – | µV |
| **Noise performance** ($V_P$ = 12 V) | | | | | |
| Output noise voltage (unweighted; Fig. 15) at f = 20 Hz to 20 kHz (r.m.s. value; note 5) | | | | | |
| for maximum voltage gain (note 4) | $V_{no(rms)}$ | – | 310 | – | µV |
| for $G_v$ = −16 dB (note 4) | $V_{no(rms)}$ | – | 100 | 200 | µV |
| Output noise voltage; weighted as DIN 45405 of 1981, CCIR recommendation 468-2 (peak value) | | | | | |
| for maximum voltage gain (note 4) | $V_{no(m)}$ | – | 940 | – | µV |
| for maximum emphasis of bass and treble (contour off; $G_v$ = −40 dB) | $V_{no(m)}$ | – | 400 | – | µV |

| parameter | symbol | min. | typ. | max. | unit |
|---|---|---|---|---|---|
| **Noise performance** ($V_P$ = 15 V) | | | | | |
| Output noise voltage (unweighted; Fig. 15) at f = 20 Hz to 20 kHz (r.m.s. value; note 5) | | | | | |
| for maximum voltage gain (note 4) | $V_{no(rms)}$ | – | 350 | – | μV |
| for $G_v$ = 16 dB (note 4) | $V_{no(rms)}$ | – | 110 | 220 | μV |
| Output noise voltage; weighted as DIN 45405 of 1981, CCIR recommendation 468-2 (peak value) | | | | | |
| for maximum voltage gain (note 4) | $V_{no(m)}$ | – | 980 | – | μV |
| for maximum emphasis of bass and treble (contour off; $G_v$ = −40 dB) | $V_{no(m)}$ | – | 420 | – | μV |

**Notes to characteristics**

1. Equation for input resistance (see also Fig. 4)

$$R_i = \frac{160\ k\Omega}{1 + G_v}\ ;\ G_{v\ max} = 12.$$

2. Frequencies below 200 Hz and above 5 kHz have reduced voltage swing, the reduction at 40 Hz and at 16 kHz is 30%.
3. In the event of bass boosting the output signal handling is reduced. The reduction is 1 dB for maximum bass boost.
4. Linear frequency response.
5. For peak values add 4,5 dB to r.m.s. values.

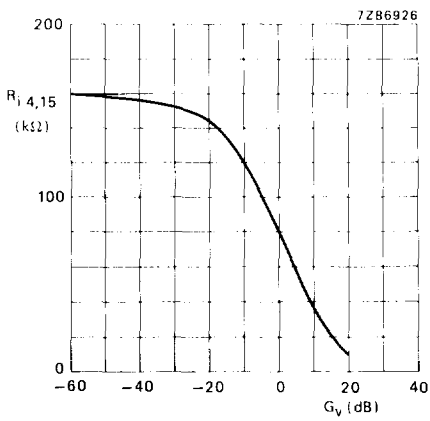



Fig. 4 Input resistance ($R_i$) as a function of gain of volume control ($G_v$). Measured in Fig. 1.

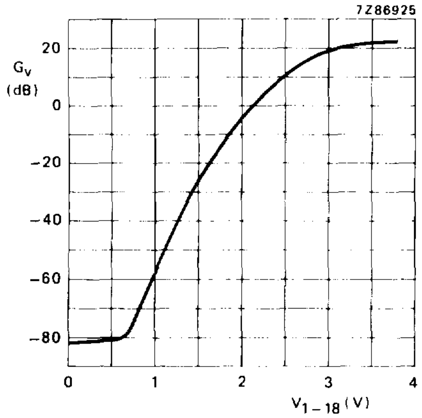



Fig. 5 Volume control curve; voltage gain ($G_V$) as a function of control voltage ($V_{1\text{-}18}$). Measured in Fig. 1 (internal potentiometer supply from pin 17 used); $V_P$ = 8,5 V; f = 1 kHz.

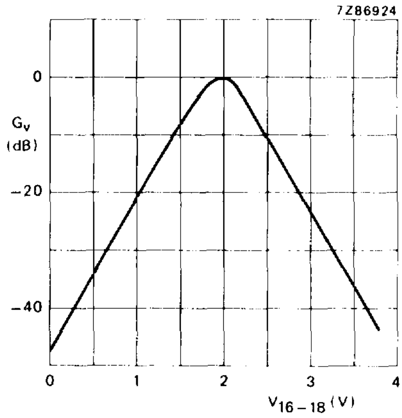



Fig. 6 Balance control curve; voltage gain ($G_V$) as a function of control voltage ($V_{16\text{-}18}$). Measured in Fig. 1 (internal potentiometer supply from pin 17 used); $V_P$ = 8,5 V.

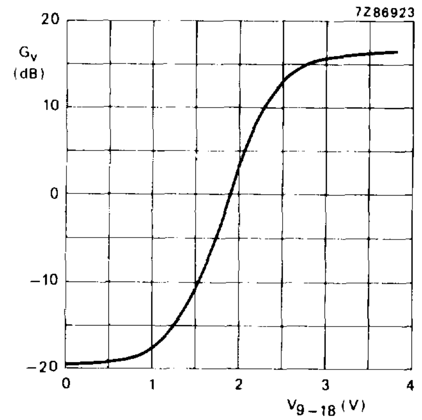



Fig. 7 Bass control curve; voltage gain ($G_V$) as a function of control voltage ($V_{9\text{-}18}$). Measured in Fig. 1 with single-pole filter (internal potentiometer supply from pin 17 used); $V_P$ = 8,5 V; f = 40 Hz.

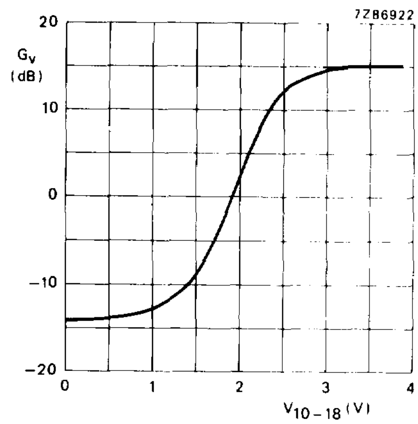



Fig. 8 Treble control curve; voltage gain ($G_V$) as a function of control voltage ($V_{10\text{-}18}$). Measured in Fig. 1 (internal potentiometer supply from pin 17 used); $V_P$ = 8,5 V; f = 16 kHz.

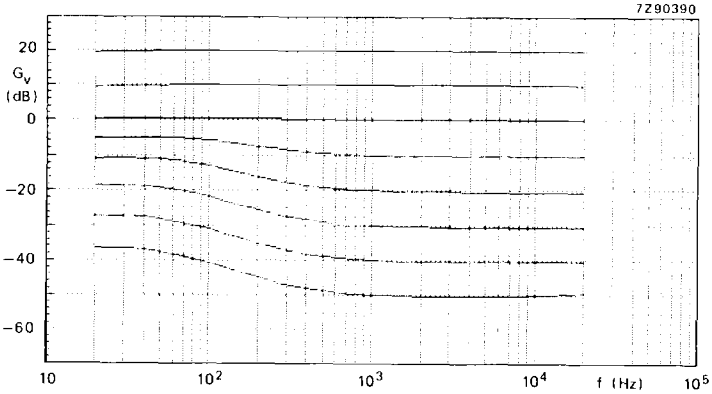



Fig. 9 Contour frequency response curves; voltage gain ($G_V$) as a function of audio input frequency. Measured in Fig. 1 with single-pole filter; $V_P$ = 8,5 V.

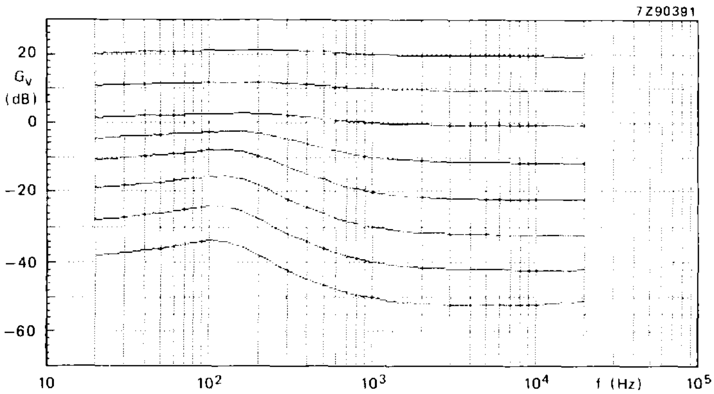



Fig. 10 Contour frequency response curves; voltage gain ($G_V$) as a function of audio input frequency. Measured in Fig. 1 with double-pole filter; $V_P$ = 8,5 V.

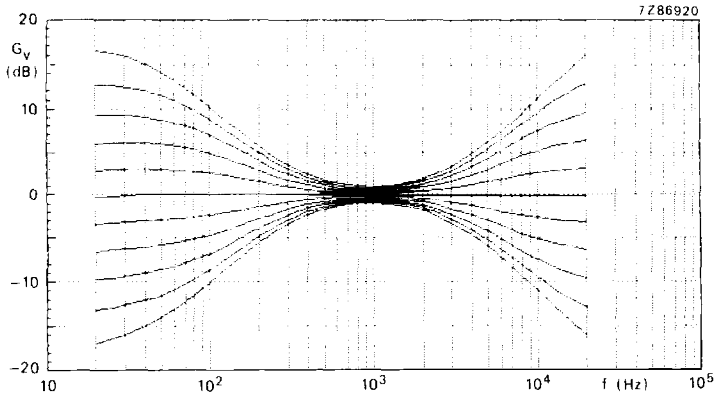



Fig. 11 Tone control frequency response curves; voltage gain ($G_V$) as a function of audio input frequency. Measured in Fig. 1 with single-pole filter; $V_P$ = 8,5 V.

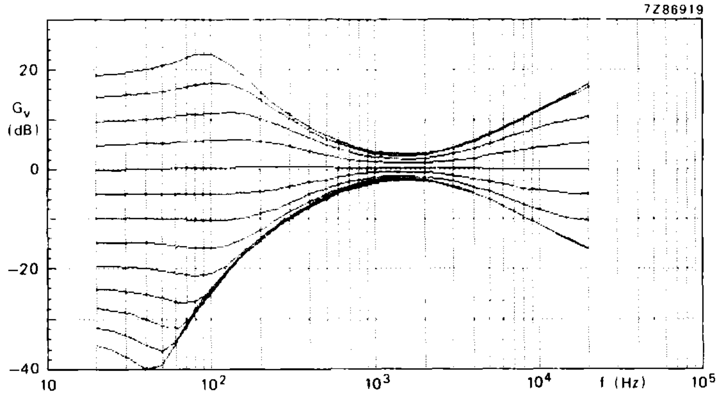



Fig. 12 Tone control frequency response curves; voltage gain ($G_V$) as a function of audio input frequency. Measured in Fig. 1 with double-pole filter; $V_P$ = 8,5 V.

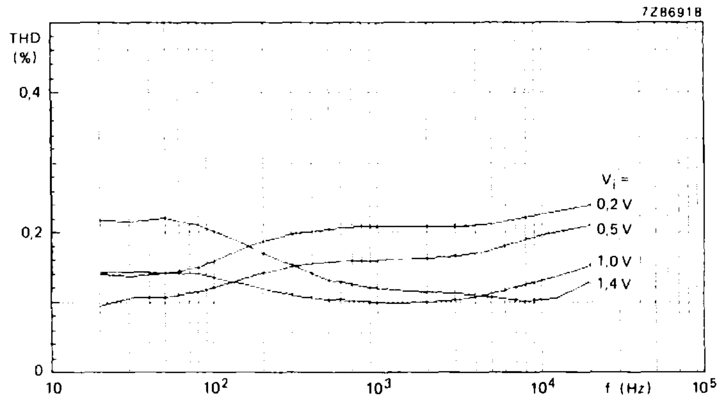



Fig. 13 Total harmonic distortion (THD); as a function of audio input frequency. Measured in Fig. 1; $V_P$ = 8,5 V; volume control voltage gain at

$$G_V = 20 \log \frac{V_o}{V_i} = 0 \text{ dB}.$$

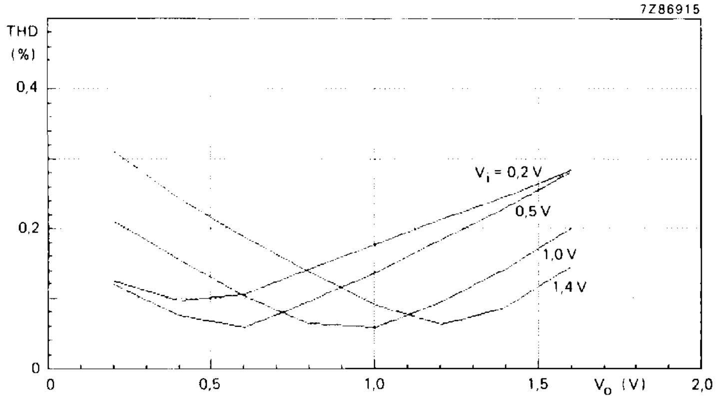
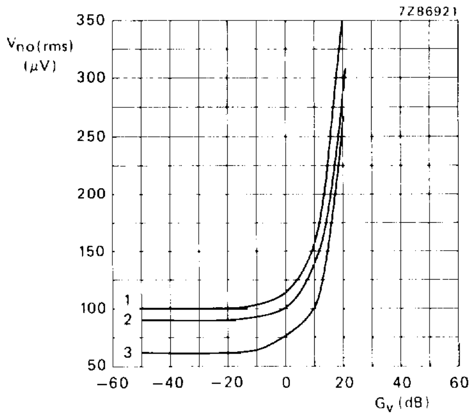



Fig. 14 Total harmonic distortion (THD); as a function of output voltage ($V_o$). Measured in Fig. 1; $V_P$ = 8,5 V; $f_i$ = 1 kHz.




(1) $V_P$ = 15 V.
(2) $V_P$ = 12 V.
(3) $V_P$ = 8,5 V.

Fig. 15 Noise output voltage ($V_{no(rms)}$; unweighted); as a function of voltage gain ($G_v$). Measured in Fig. 1; f = 20 Hz to 20 kHz.