



LC75373E

Electronic Volume Control for Car Stereo Systems



Overview

The LC75373E is an electronic volume control that can implement volume, balance, fader, bass/treble + super bass, loudness, input switching, and input/output level control functions with a minimal number of external components.

Functions

- Volume: Provides 81 positions, from 0 dB to -79 dB (in 1-dB steps) and $-\infty$. A balance function can be implemented by controlling the left and right channels independently.
- Fader: This function can attenuate either the rear or the front outputs over 16 positions. (From 0 to -20 dB in 2-dB steps, from -20 to -25 dB in one 5-dB step, from -25 to -45 dB in 10-dB steps, -60 dB, and $-\infty$)
- Bass/treble: Forms an NF-type tone control circuit with the addition of external capacitors. The base and treble controls each have 15 positions.
- Input gain: The input signal can be amplified from 0 dB to +18.75 dB in 1.25 dB steps.
- Output gain: One of two output of 0 dB and +6.5 dB can be selected for fader output.
- Input switch: The signal can be selected from one of four inputs for each of the left and right channels.
- Super bass: The position of super bass can be controlled in 11 steps.

Features

- On-chip buffer amplifiers for a minimum of external components.
- Built-in reference voltage generation circuit
- Serial data input: Supports CCB format communication with the system controller.

Specifications

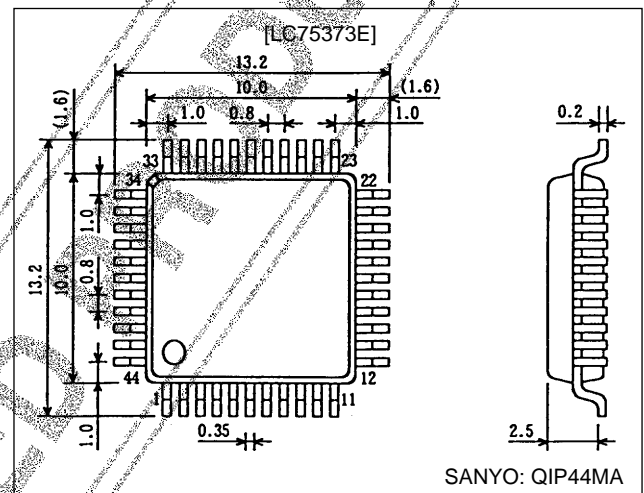
Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$, $V_{SS} = 0\text{ V}$

| Parameter | Symbol | Conditions | Ratings | Unit |
|------------------------|---------------------|------------|----------------------------------|------------------|
| Maximum supply voltage | $V_{DD\text{ max}}$ | V_{DD} | 11 | V |
| Maximum input voltage | $V_{IN\text{ max}}$ | CL, DI, CE | $V_{SS} - 0.3$ to $V_{DD} + 0.3$ | V |
| Operating temperature | T_{opr} | | -40 to +85 | $^\circ\text{C}$ |
| Storage temperature | T_{stg} | | -50 to +125 | $^\circ\text{C}$ |

Package Dimensions

unit: mm

3148-QFP44MA



- CCB is a trademark of SANYO ELECTRIC CO., LTD.
- CCB is SANYO's original bus format and all the bus addresses are controlled by SANYO.

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Allowable Operating Ranges at $T_a = 25^\circ\text{C}$, $V_{SS} = 0\text{ V}$

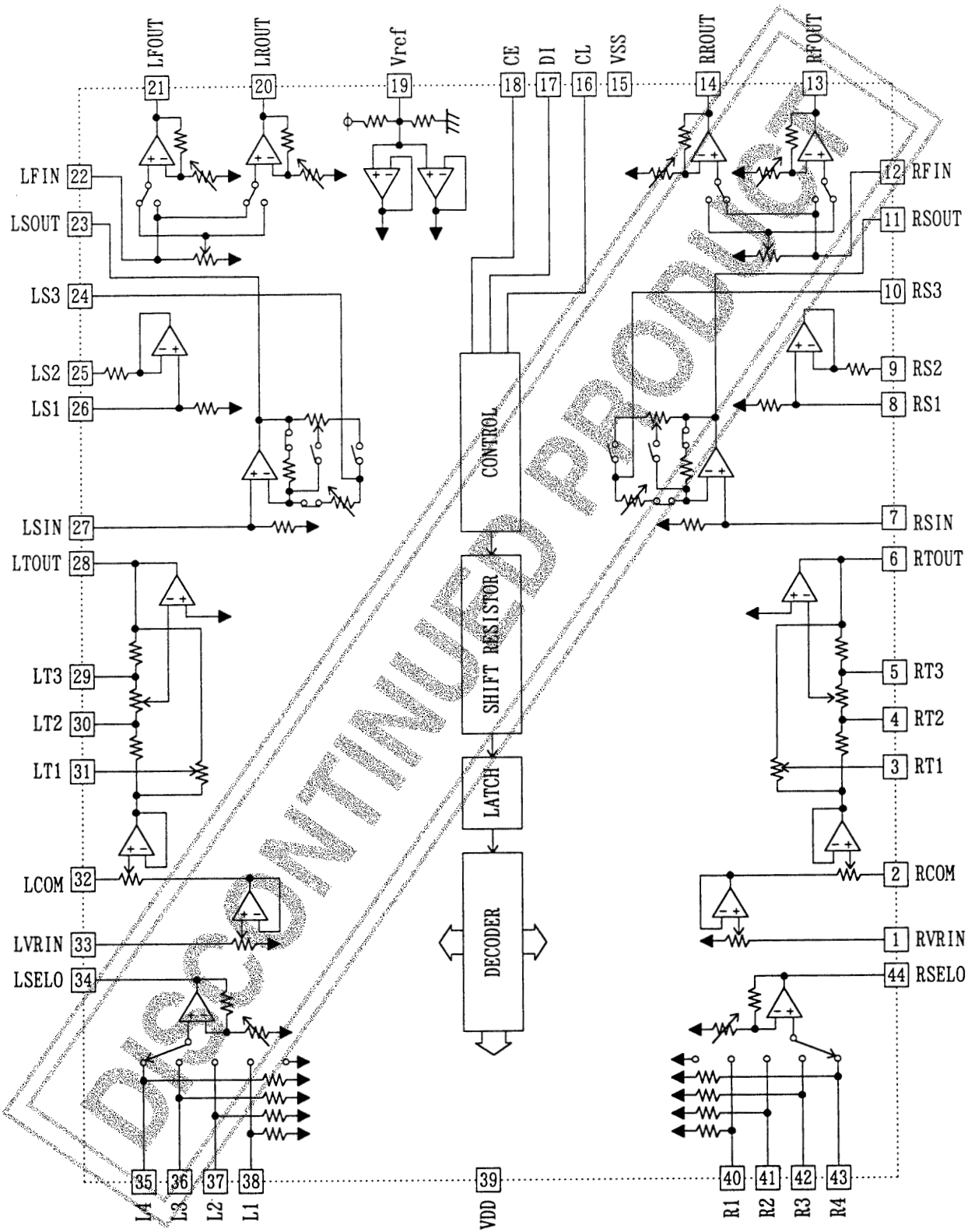
| Parameter | Symbol | Conditions | min | typ | max | Unit |
|--------------------------|-------------|--|----------|-----|----------|---------------|
| Supply voltage | V_{DD} | V_{DD} | 6.0 | | 10.5 | V |
| Input high-level voltage | V_{IH} | CL, DI, CE | 4.0 | | V_{DD} | V |
| Input low-level voltage | V_{IL} | CL, DI, CE | V_{SS} | | 1.0 | V |
| Input voltage amplitude | V_{IN} | CL, DI, CE, LVRIN, RVRIN, L1 to L4, R1 to R4 LFIN, RFIN, LSIN, RSIN | V_{SS} | | V_{DD} | Vp-p |
| Input pulse width | t_{PW} | CL | 1 | | | μs |
| Setup time | t_{setup} | CL, DI, CE | 1 | | | μs |
| Hold time | t_{hold} | CL, DI, CE | 1 | | | μs |
| Operating frequency | fopg | CL | | | 500 | kHz |

Electrical Characteristics at $T_a = 25^\circ\text{C}$, $V_{DD} = 8\text{ V}$, $V_{SS} = 0\text{ V}$

| Parameter | Symbol | Conditions | min | typ | max | Unit |
|---------------------------------|----------------|---|---------|------------|----------|---------------|
| [Input Block] | | | | | | |
| Maximum input gain | $G_{in\ max}$ | | | +18.75 | | dB |
| Step resolution | G_{step} | | | +1.25 | | dB |
| [Output Block] | | | | | | |
| Maximum output gain | $G_{out\ max}$ | | | +6.5 | | dB |
| [Volume Control Block] | | | | | | |
| Step resolution | AT_{step} | | | 1 | | dB |
| Step error | AT_{err} | step = 0 to -20 dB | -1 | 0 | +1 | dB |
| | | step = -20 to -50 dB | -3 | 0 | +3 | dB |
| [Fader Volume Block] | | | | | | |
| Step resolution | AT_{step} | step = 0 to -20 dB | | 2 | | dB |
| | | step = -20 to -25 dB | | 5 | | dB |
| | | step = -25 to -45 dB | | 10 | | dB |
| Step error | AT_{err} | step = 0 to -45 dB | -2 | 0 | +2 | dB |
| | | step = -45 to -60 dB | -3 | 0 | +3 | dB |
| Output load resistance | R_L | | 10 | | | k Ω |
| [Bass/Treble Control Block] | | | | | | |
| Bass control range | G_{bass} | Max. boost/cut | ± 9 | ± 10.5 | ± 12 | dB |
| Treble control range | G_{tre} | Max. boost/cut | ± 8 | ± 10.5 | ± 13 | dB |
| [Super Bass Block 1 (Type GEQ)] | | | | | | |
| Control range | C_{range} | Max. boost | | +17 | | dB |
| Step resolution | AT_{step} | | | +1.7 | | dB |
| [Super Bass Block 2 (Type T)] | | | | | | |
| Control range | C_{range} | Max. boost | | +20 | | dB |
| Step resolution | AT_{step} | | | +2.0 | | dB |
| [Overall Characteristics] | | | | | | |
| Total harmonic distortion | THD | $V_{IN} = 1\text{ V}_{rms}$, $f = 1\text{ kHz}$, all settings flat overall | | 0.003 | 0.01 | % |
| Crosstalk | CT | $V_{IN} = 1\text{ V}_{rms}$, $f = 1\text{ kHz}$, all settings flat overall, $R_g = 1\text{ k}\Omega$ | | 80.5 | | dB |
| Output at maximum attenuation | $V_O\ min$ | $V_{IN} = 1\text{ V}_{rms}$, $f = 1\text{ kHz}$, main volume at $-\infty$ | | -80 | | dB |
| Output noise voltage | V_{N1} | All settings flat overall (IHF-A), $R_g = 1\text{ k}\Omega$ | | 8 | | μV |
| | V_{N2} | All settings flat overall (DIN-AUDIO), $R_g = 1\text{ k}\Omega$ | | 10 | | μV |
| Input high-level current | I_{IH} | CL, DI, CE: $V_{IN} = 8\text{ V}$ | | | 10 | μA |
| Input low-level current | I_{IL} | CL, DI, CE: $V_{IN} = 0\text{ V}$ | -10 | | | μA |

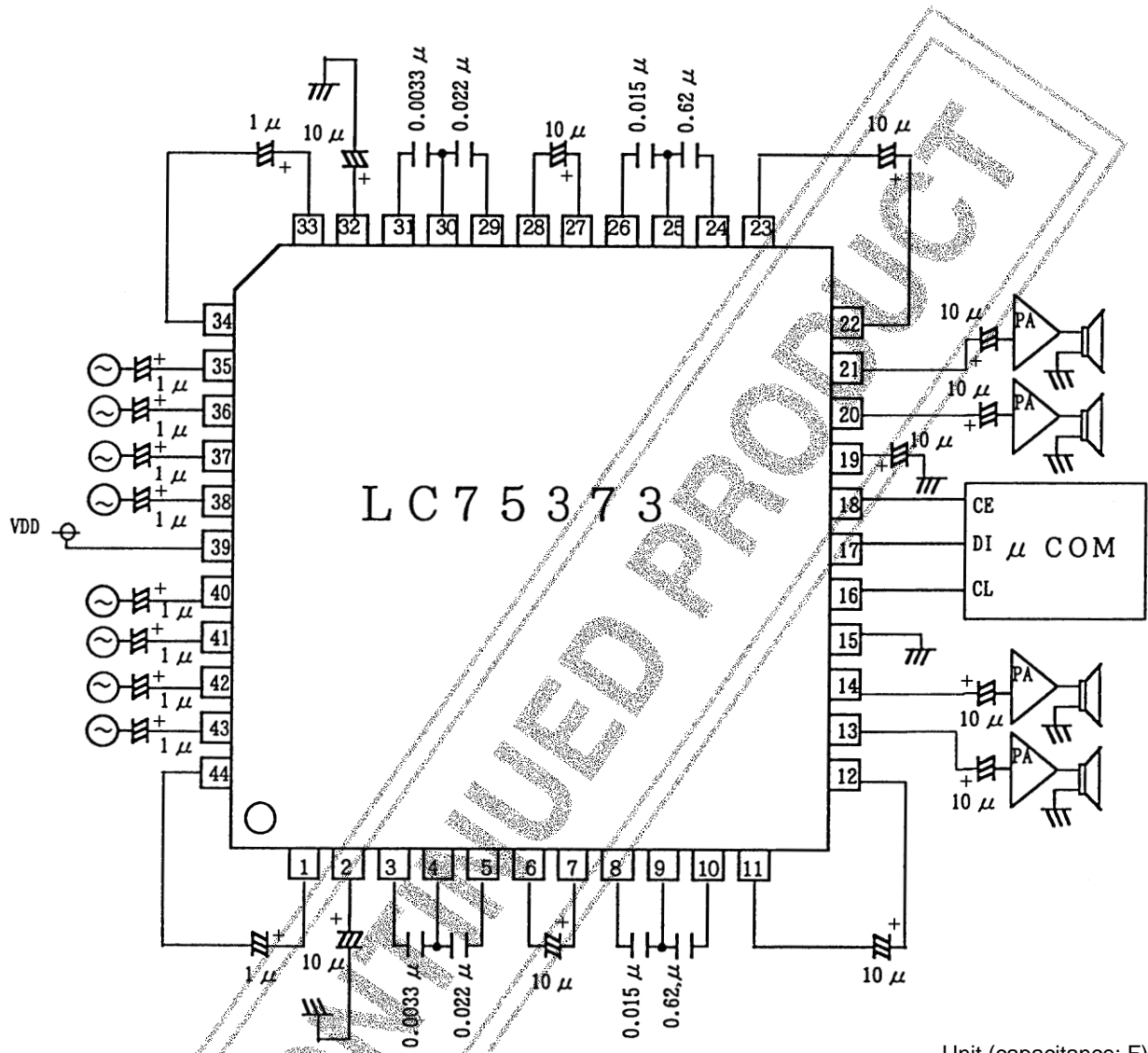
Note: Values in parenthesis are targets and will be fixed after evaluation.

Equivalent Circuit Block Diagram



Sample Application Circuit

1. When super bass circuit 1 (Type GEQ) is used

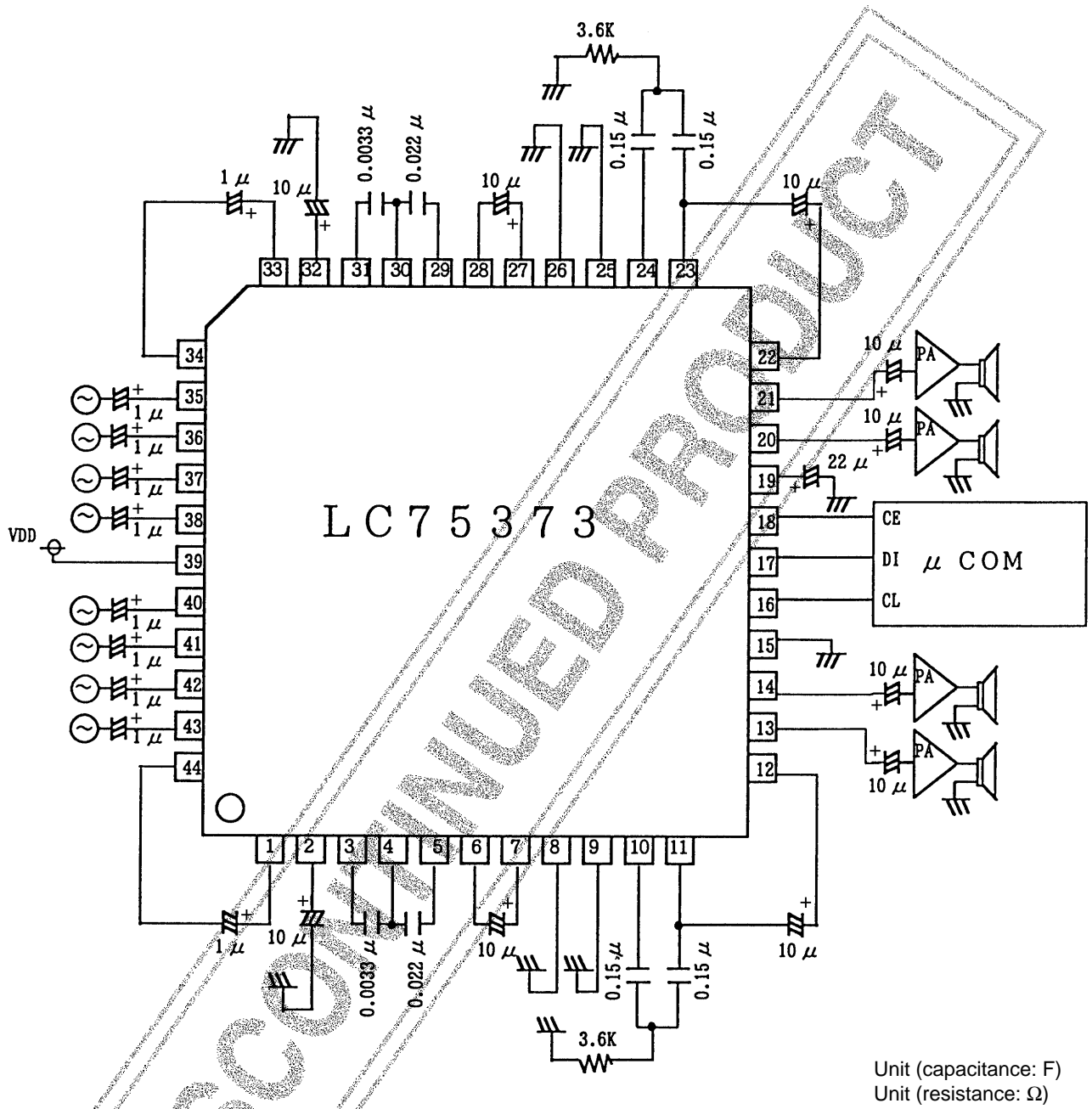


Unit (capacitance: F)

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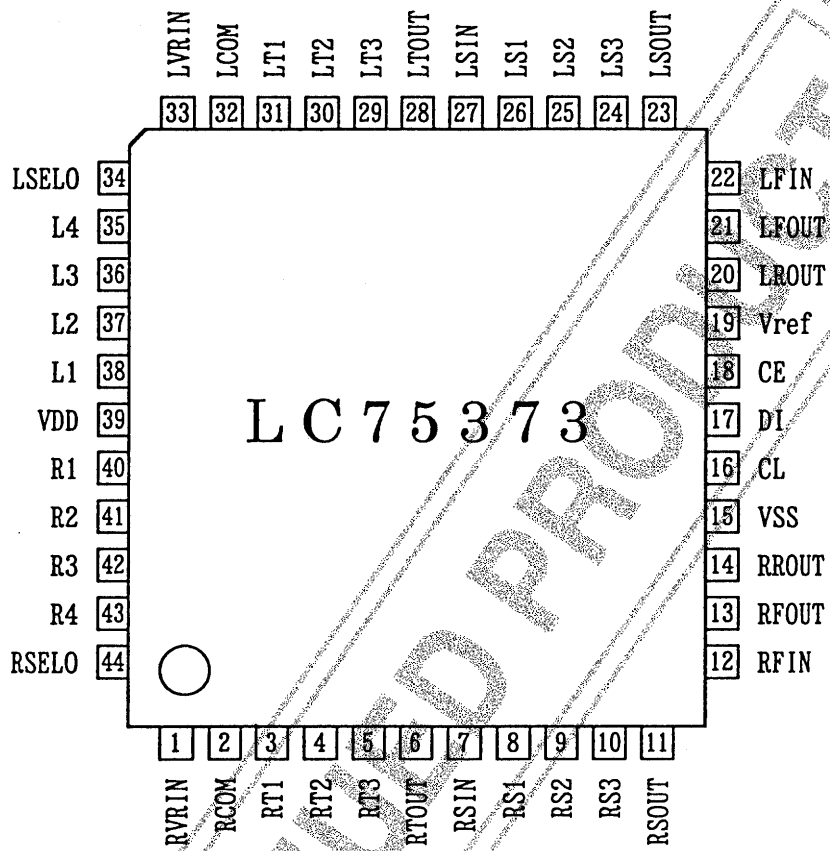
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2. When super bass circuit 2 (Type T) is used



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Pin Assignment



Top view

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Pin Functions

| Pin No. | Symbol | Function | Note |
|--------------------------------|--|---|------|
| 19 | Vref | <ul style="list-style-type: none"> • 1/2 V_{DD} voltage generation block. A capacitor must be connected between Vref and V_{SS} to suppress power supply ripple. | |
| 20 21 14 13 | LROUT LFOUT RROUT RFOUT | <ul style="list-style-type: none"> • Fader outputs. The front and rear systems can be attenuated independently. | |
| 22 12 | LFIN RFIN | <ul style="list-style-type: none"> • Fader inputs • Must be driven from low-impedance circuits. | |
| 28 6 | LTOUT RTOUT | <ul style="list-style-type: none"> • Tone control outputs | |
| 31 30 29 3 4 5 | LT1 LT2 LT3 RT1 RT2 RT3 | <ul style="list-style-type: none"> • Connections for the bass and treble compensation capacitors for the tone control circuit • Connect high-band compensation capacitors between T1 and T2. • Connect low-band compensation capacitors between T2 and T3. | |
| 26 25 24 8 9 10 | LS1 LS2 LS3 RS1 RS2 RS3 | <ul style="list-style-type: none"> • Super bass compensation capacitors | |
| 33 1 | LVRIN RVRIN | <ul style="list-style-type: none"> • 4-dB volume control inputs • These inputs must be driven from low-impedance circuits. | |

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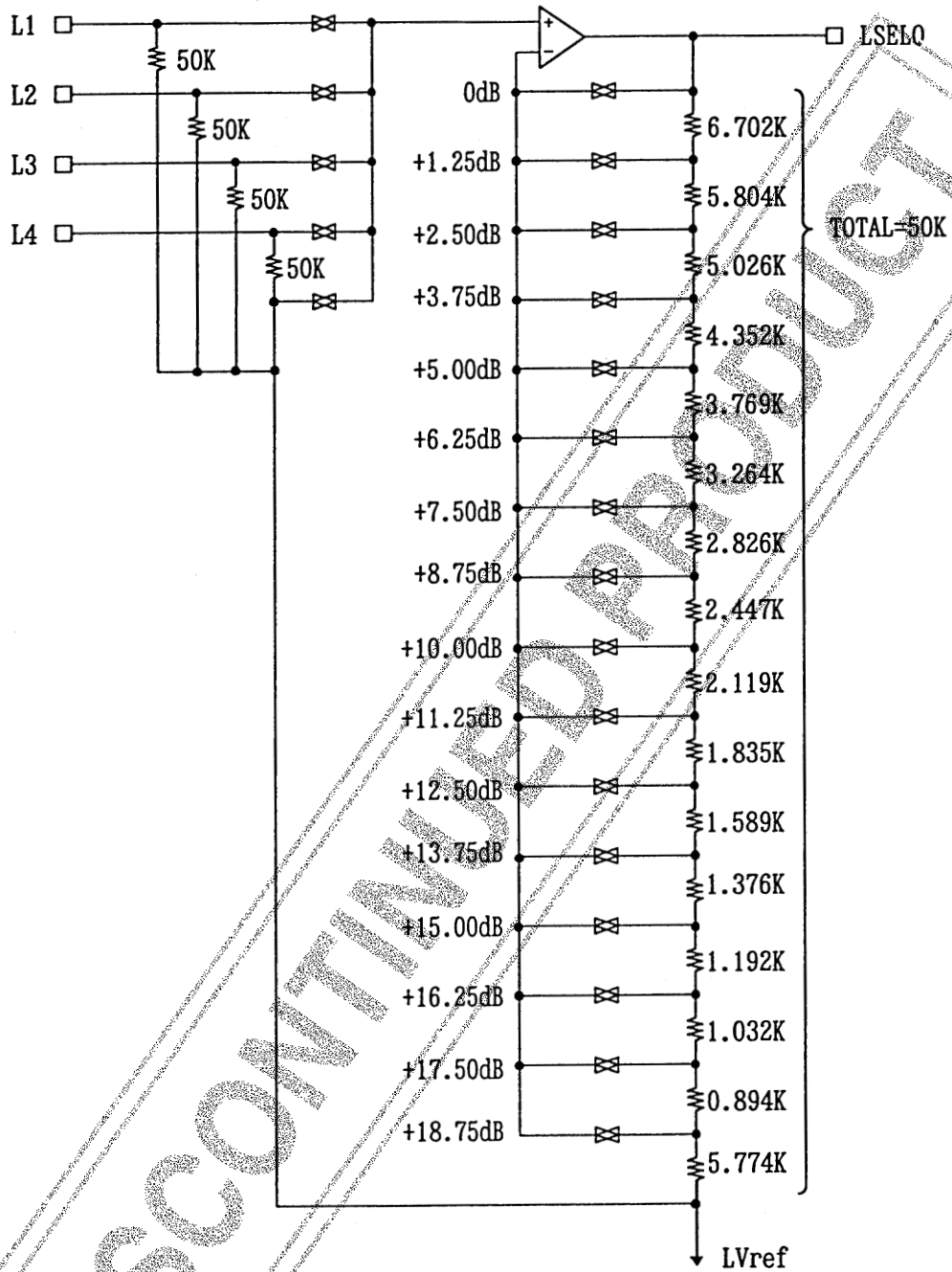
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| Pin No. | Symbol | Function | Note |
|--|--|---|------|
| 34 44 | LSELO RSELO | <ul style="list-style-type: none"> Outputs from the input selector | |
| 38 37 36 35 40 41 42 43 | L1 L2 L3 L4 R1 R2 R3 R4 | <ul style="list-style-type: none"> Signal inputs | |
| 39 | V _{DD} | Power supply connection | |
| 15 | V _{SS} | Ground | |
| 18 | CE | Chip enable. Data is latched internally at the point this pin goes from high to low. The analog switches operate at that point. Data transfer is enabled when this pin is high. | |
| 16 17 | CL DI | Inputs for the serial data and clock used for LSI control. | |
| 32 2 | LCOM RCOM | 1-dB block common outputs | |
| 27 7 | LSIN RSIN | <ul style="list-style-type: none"> Super bass inputs These inputs must be driven by low impedance circuits. | |
| 11 23 | RSOUT LSOUT | <ul style="list-style-type: none"> Super bass outputs | |

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Input Block Equivalent Circuit

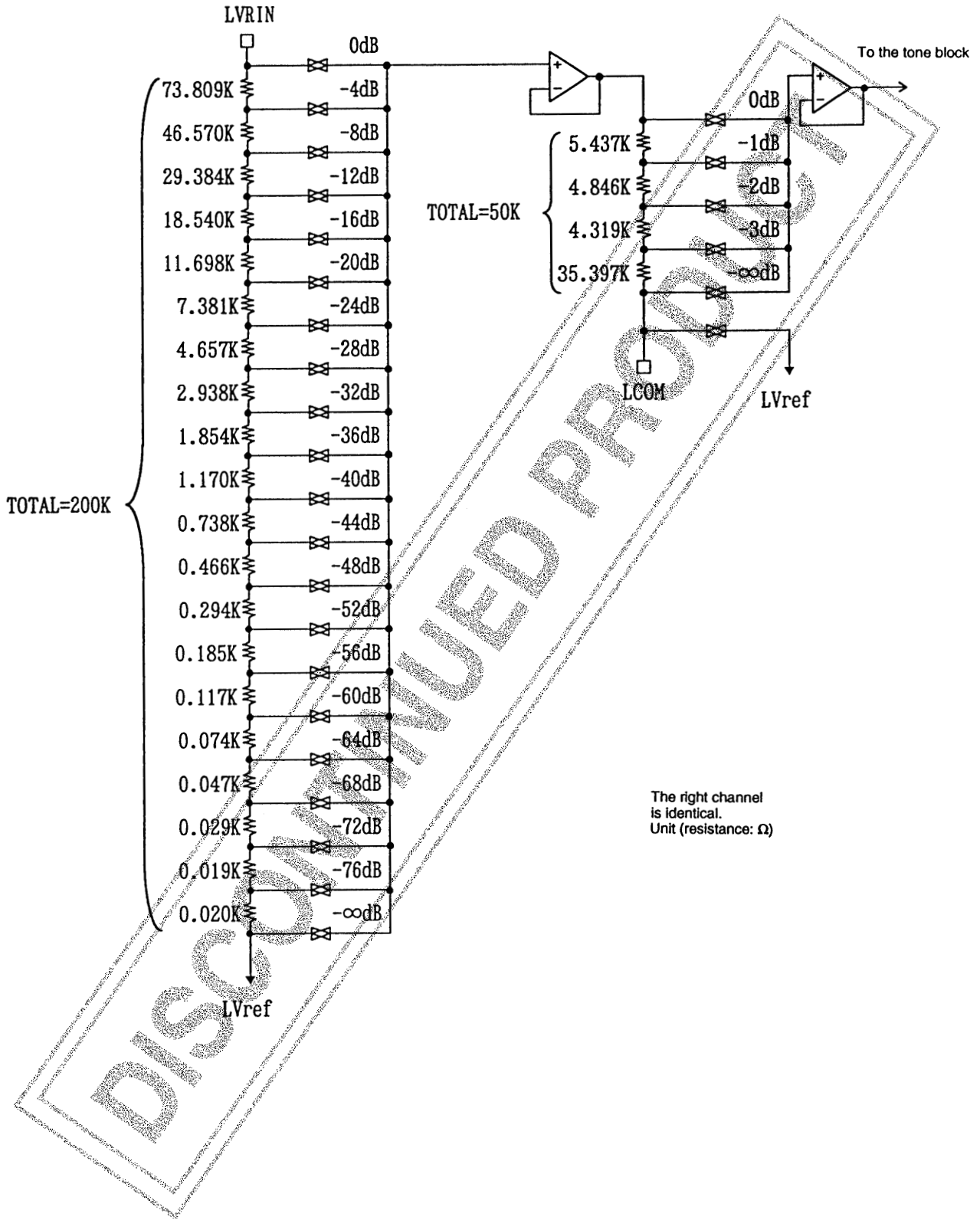


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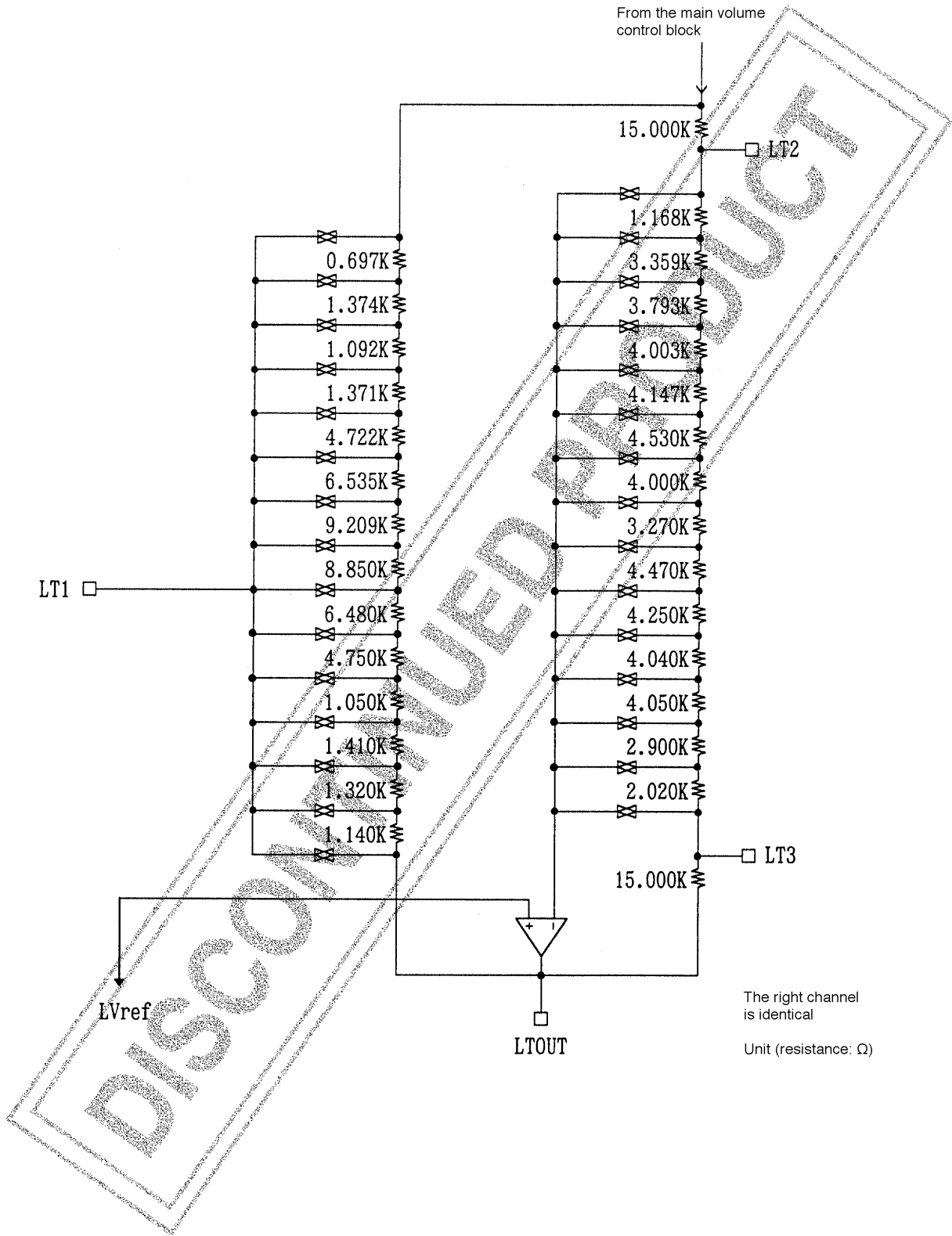
The right channel is identical.

Unit (resistance: Ω)

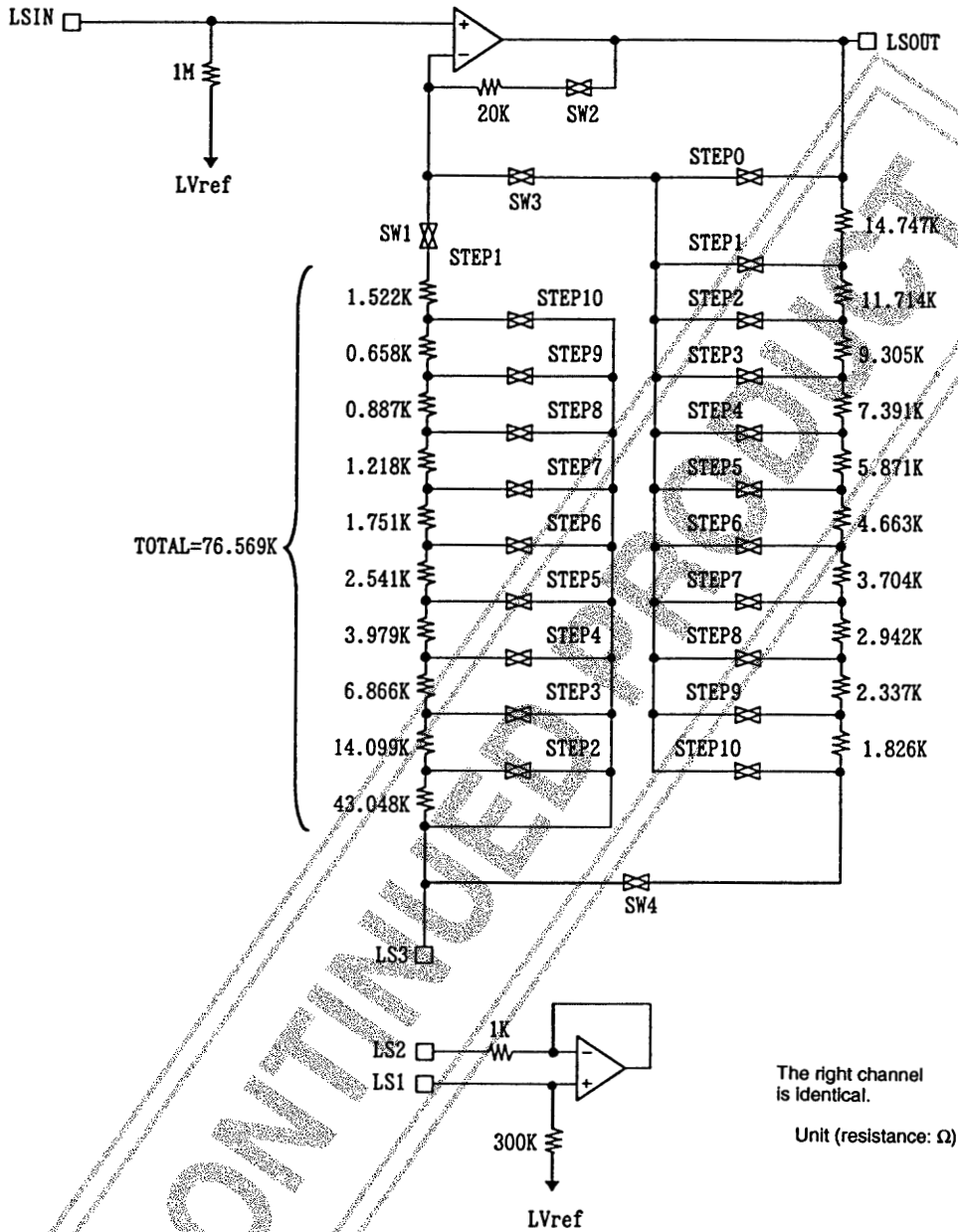
Main Volume Control Equivalent Circuit



Tone Control Block Equivalent Circuit



Super Bass Block Equivalent Circuit



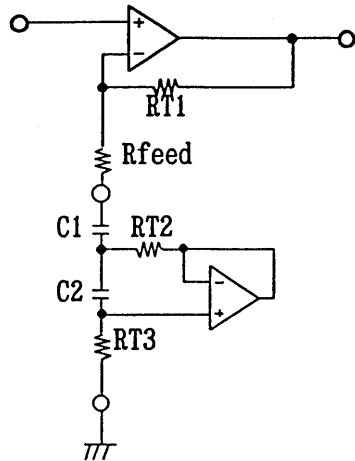
Note: Concerning super bass switching control

- If the Q for super bass 1 (Type GEQ) is to be set to a relatively large value
 SW1.....on (Note that this switch should be set to the off position only if STEP 0 data was sent.)
 SW2.....on
 SW3.....off
 SW4.....off
- If the Q for super bass 2 (Type T) can be set to a relatively small value without problem
 SW1.....off
 SW2.....off
 SW3.....on
 SW4.....on

Super Bass Block Circuit 1 External Capacitor Calculation Example

The LC75373E external capacitors function as the structural elements for simulated inductances. This section presents the equivalent circuits and the formulas used to calculate the desired center frequencies.

Simulated Inductance Equivalent Circuit



Sample Calculations

Specifications: Center frequency: $F_0 = 100 \text{ Hz}$
 Q at maximum boost: $Q_{\text{max}} = 1.05$

① Determine the sharpness Q_0 of the simulated inductance itself.

$$Q_0 = \frac{(RT2 + R_{\text{feed}})}{RT2} \quad * \quad Q_{\text{max}} \approx 2.6481$$

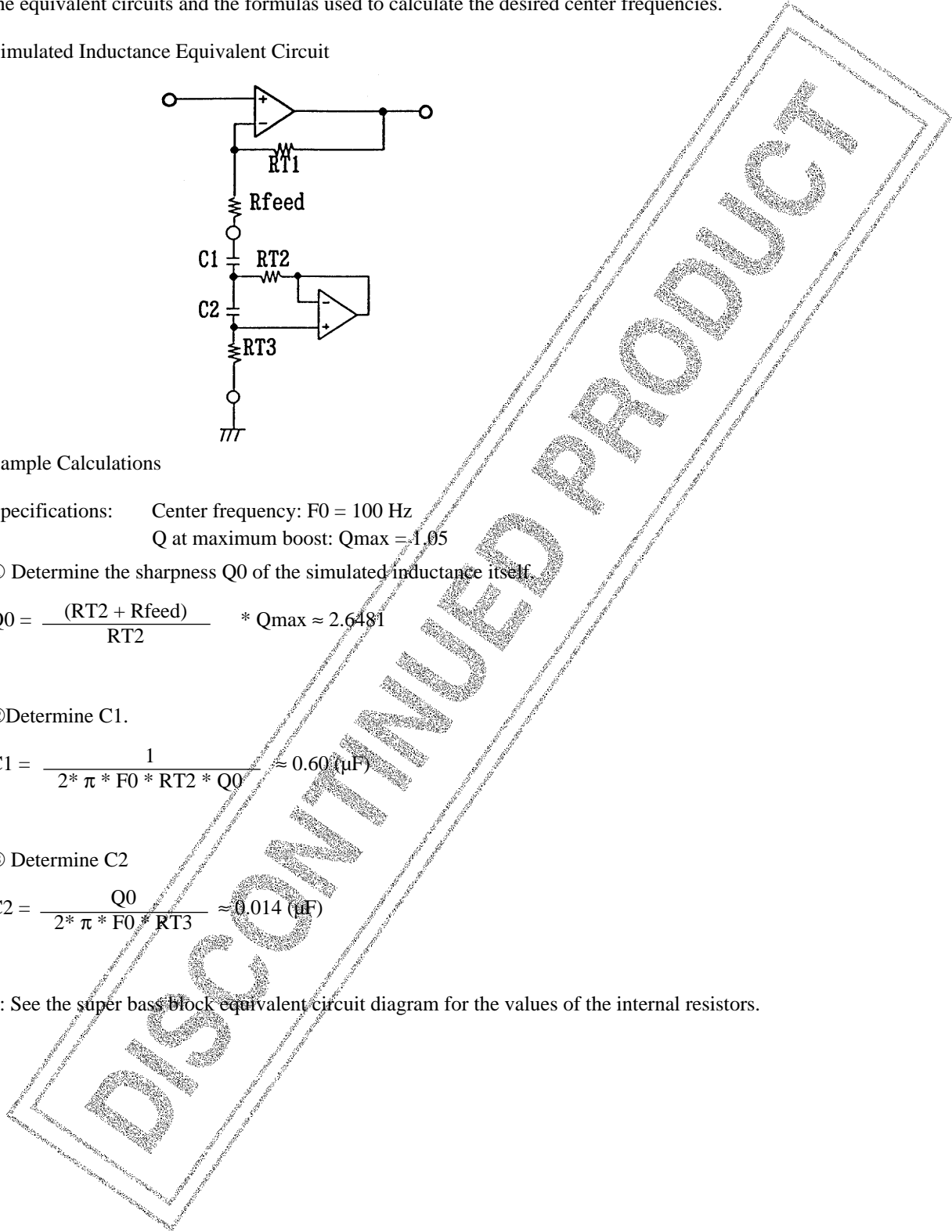
② Determine C_1 .

$$C_1 = \frac{1}{2 * \pi * F_0 * RT2 * Q_0} \approx 0.60 (\mu\text{F})$$

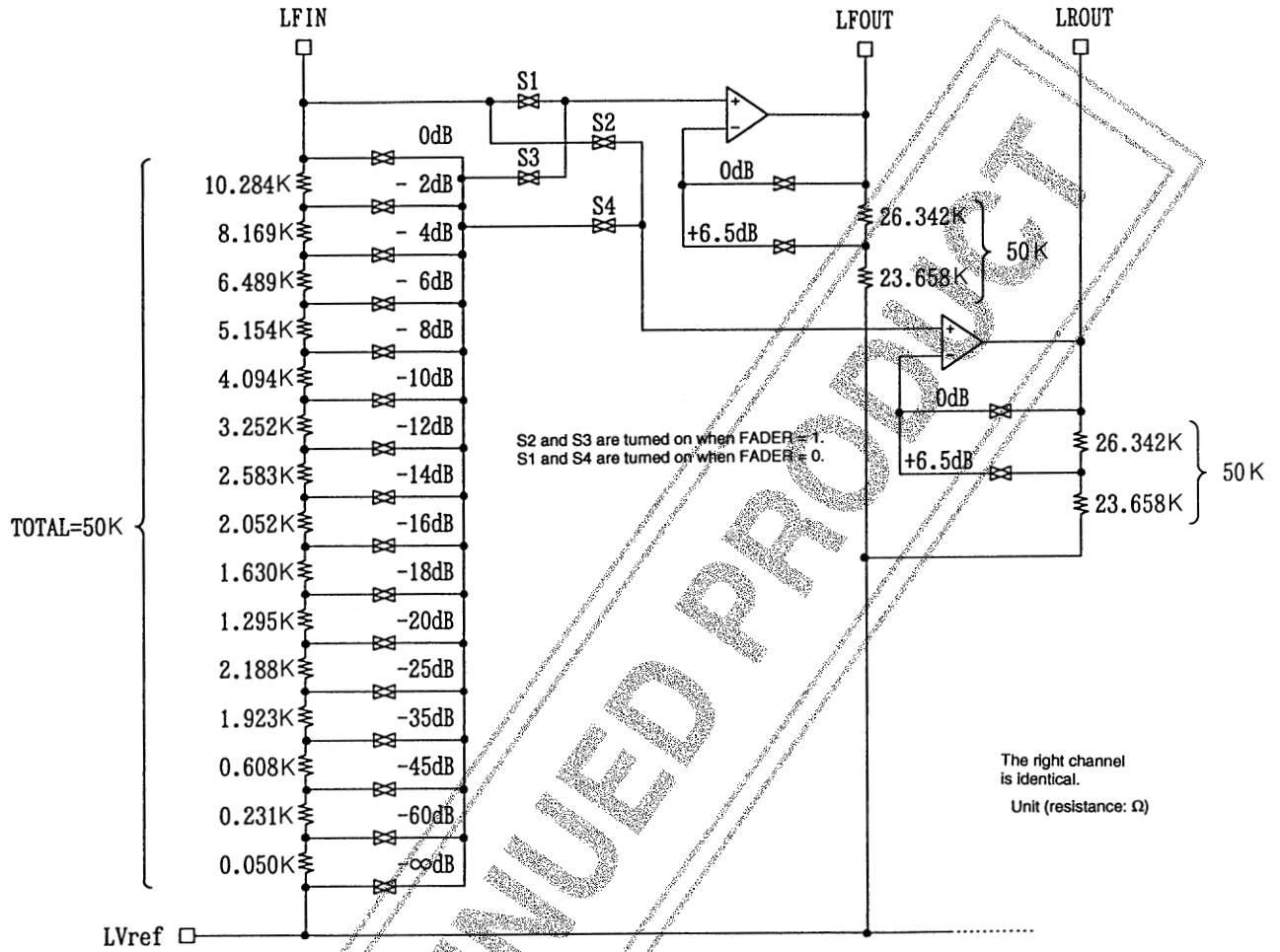
③ Determine C_2

$$C_2 = \frac{Q_0}{2 * \pi * F_0 * RT3} \approx 0.014 (\mu\text{F})$$

*: See the super bass block equivalent circuit diagram for the values of the internal resistors.



Fader Volume Control Block Equivalent Circuit

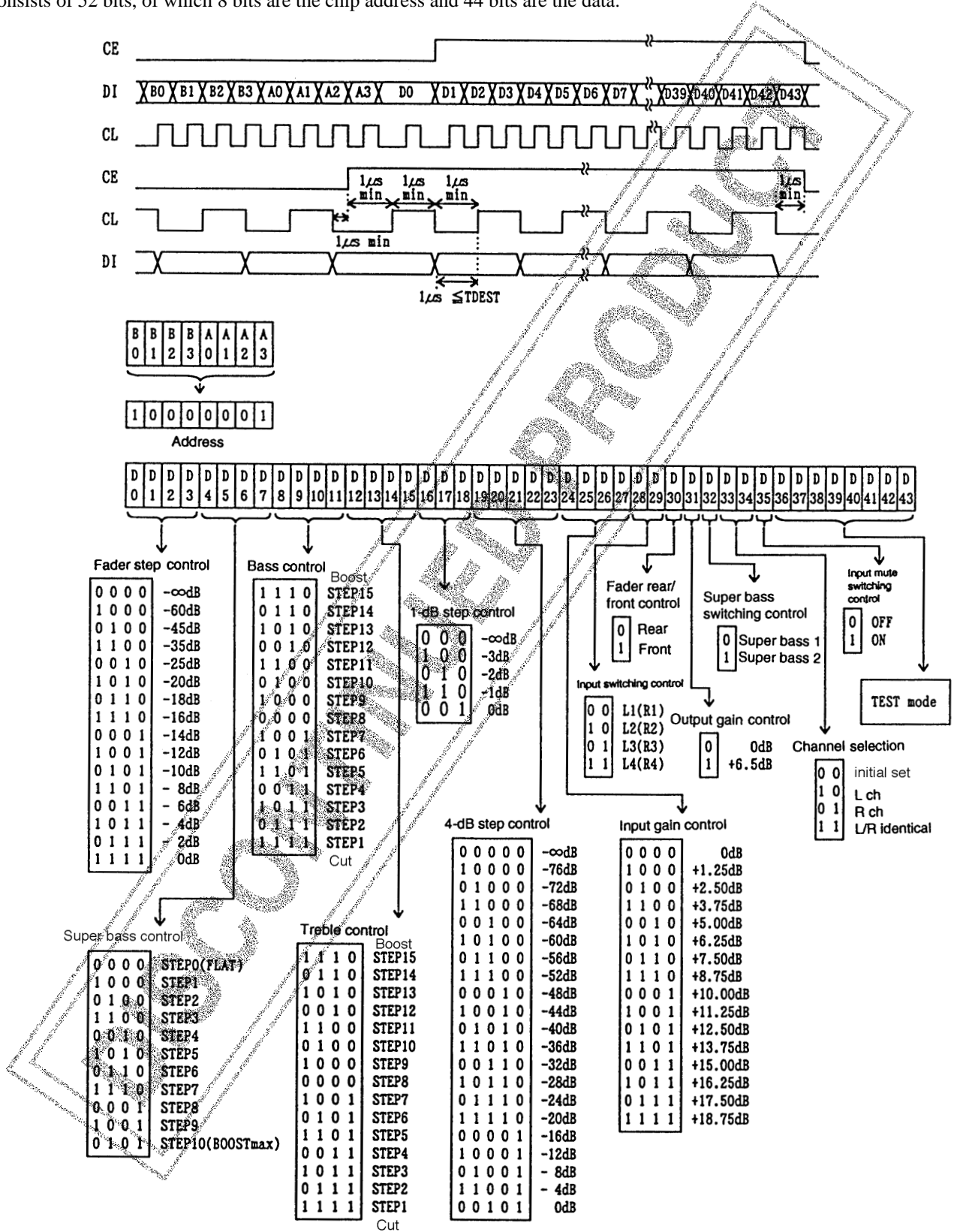


When data indicating an gain of ∞ is sent to the main volume control, 1-dB step function, S1 and S2 open, and S3 and S4 go on at the same time.

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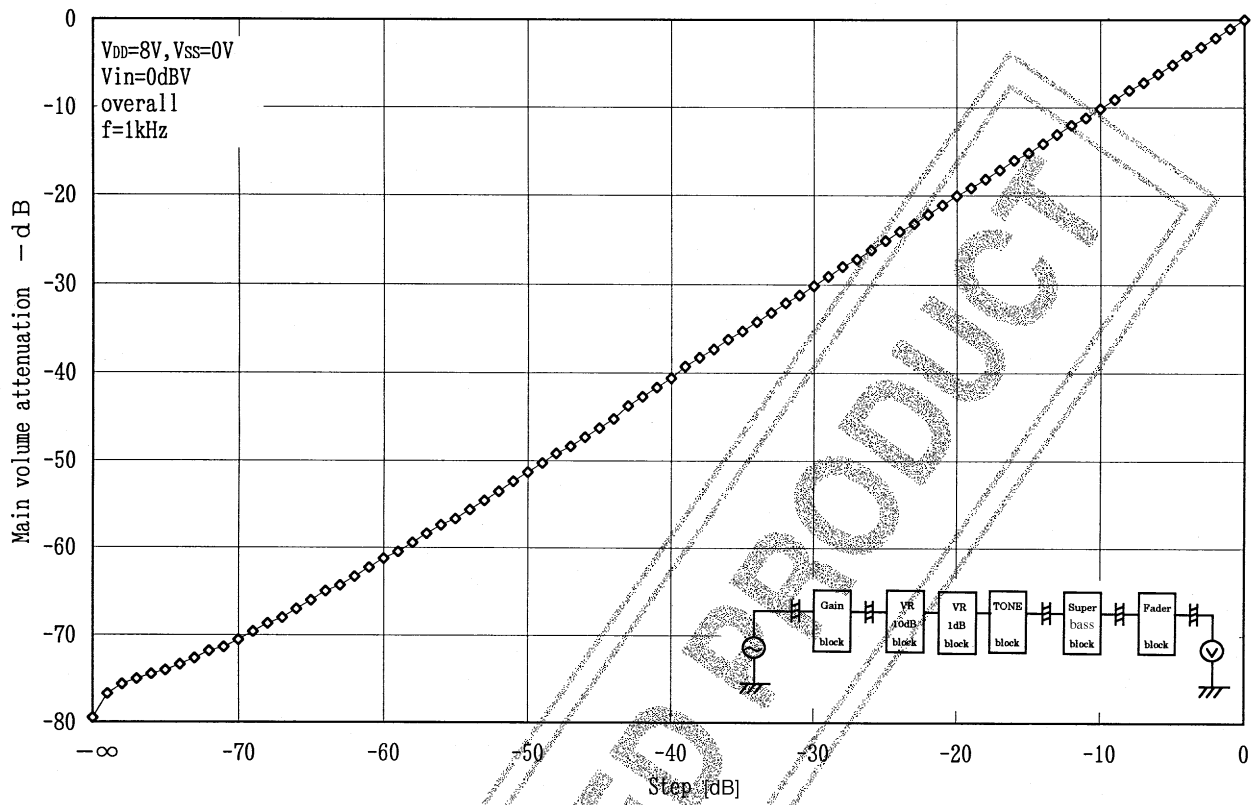
Control System Timing and Data Format

The LC75373E is controlled by applying serial data in the stipulated format to the CE, CL, and DI pins. The data consists of 52 bits, of which 8 bits are the chip address and 44 bits are the data.

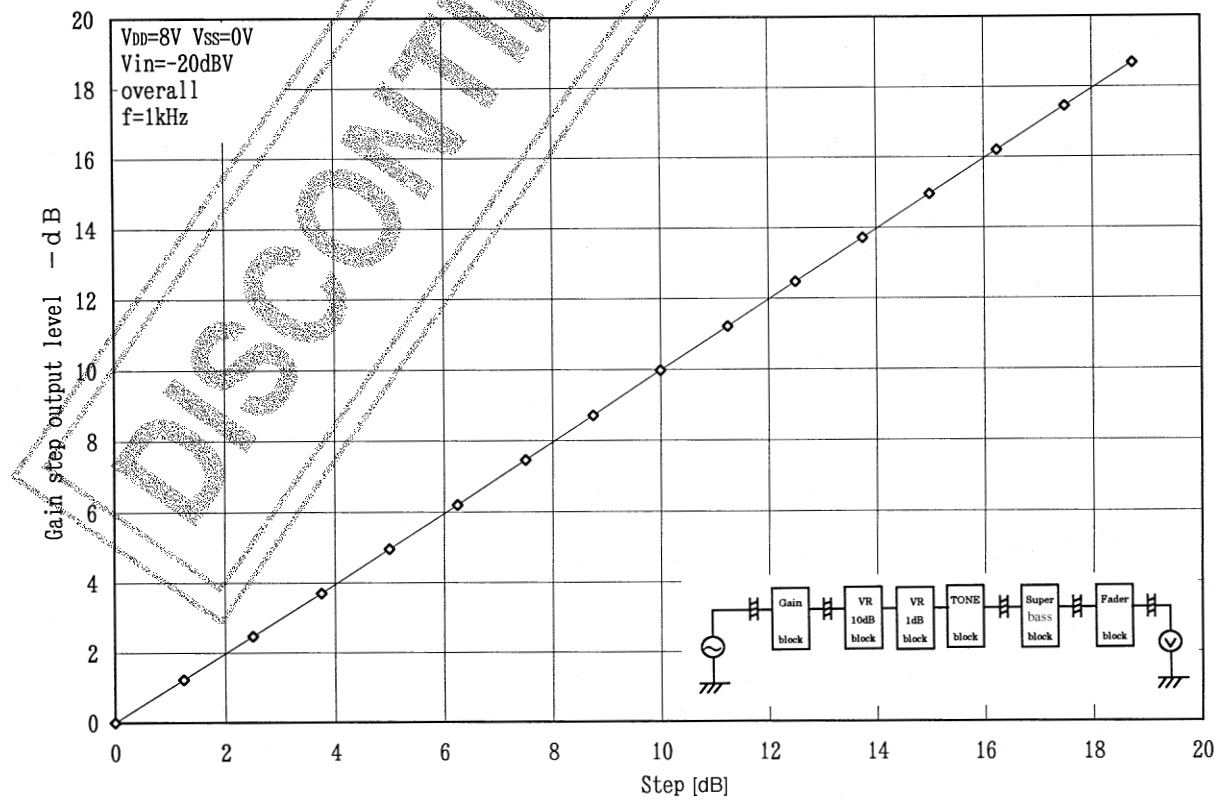


Note: 1. The bits D36 to D43 are LSI test bits and must be set to 0.
 2. Concerning super bass switching
 If the Q for super bass 1 is to be set to a relatively large value
 If the Q for super bass 2 can be set to a relatively small value without problem

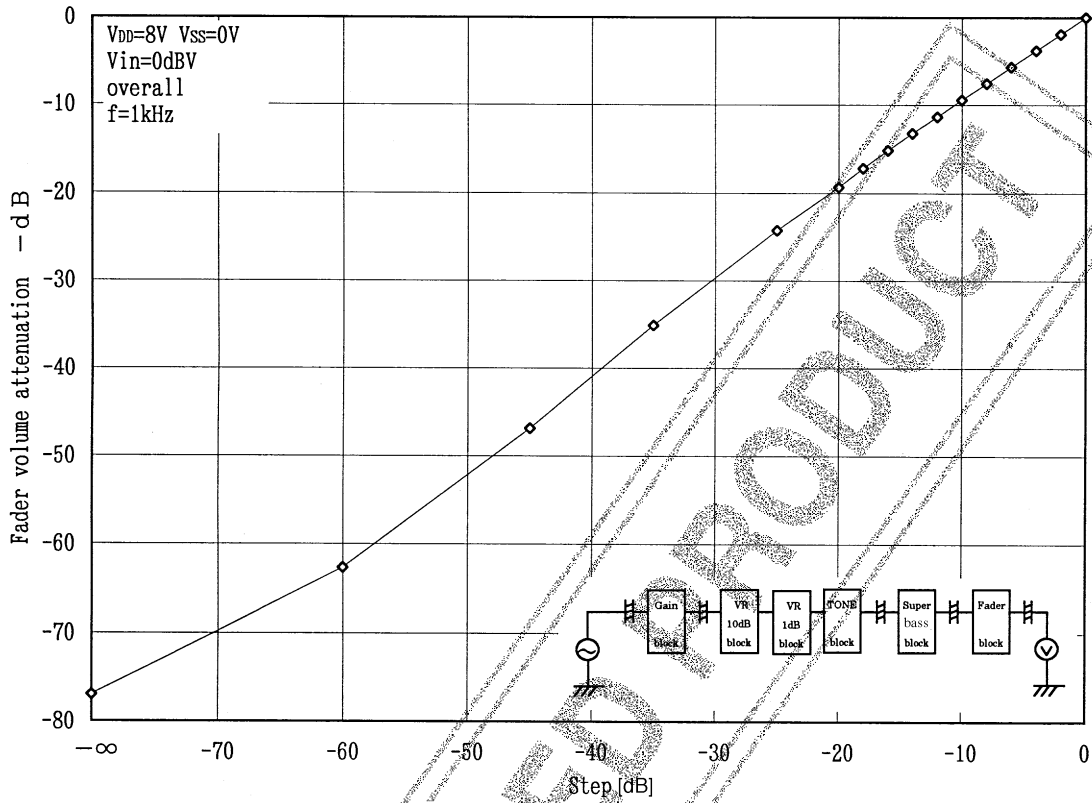
Main volume control characteristics



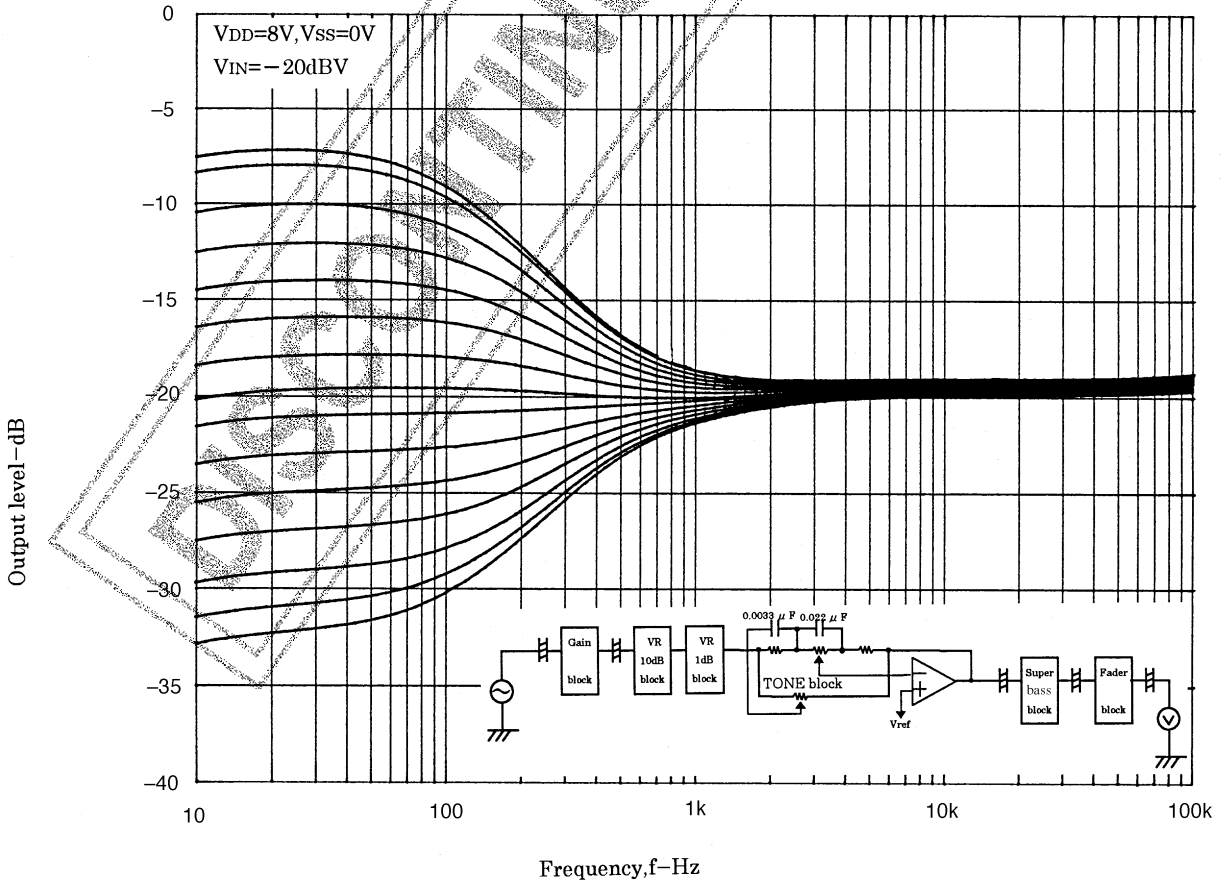
Gain step characteristics



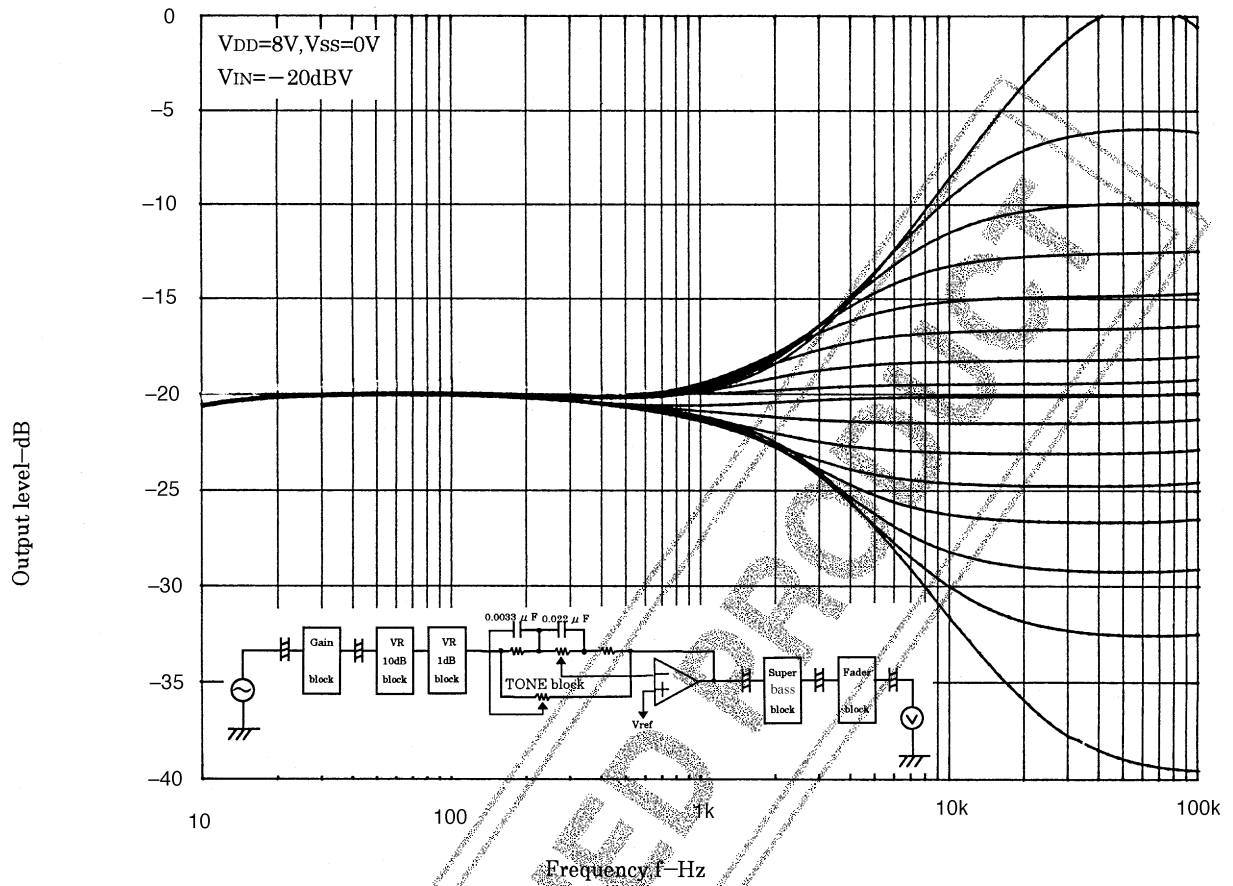
Fader volume control step characteristics



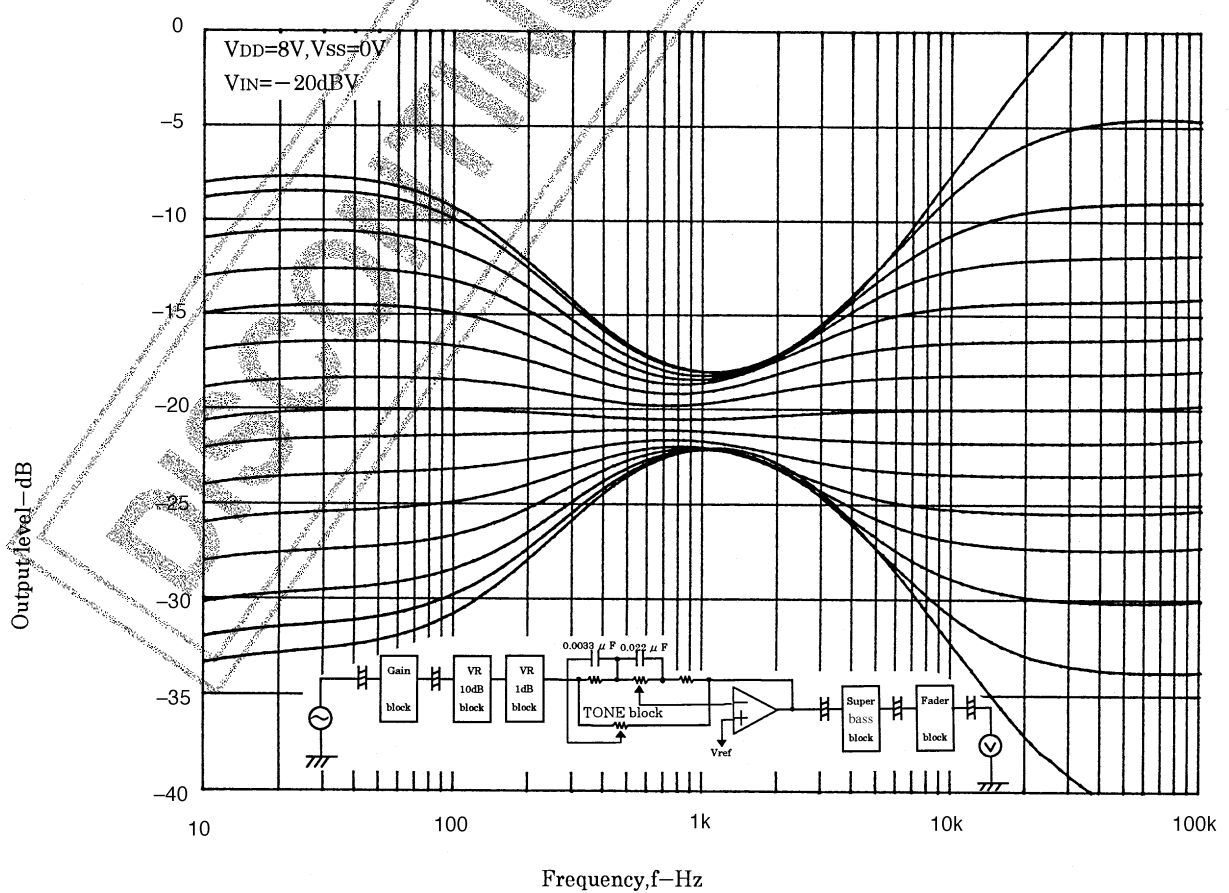
Bass control characteristics



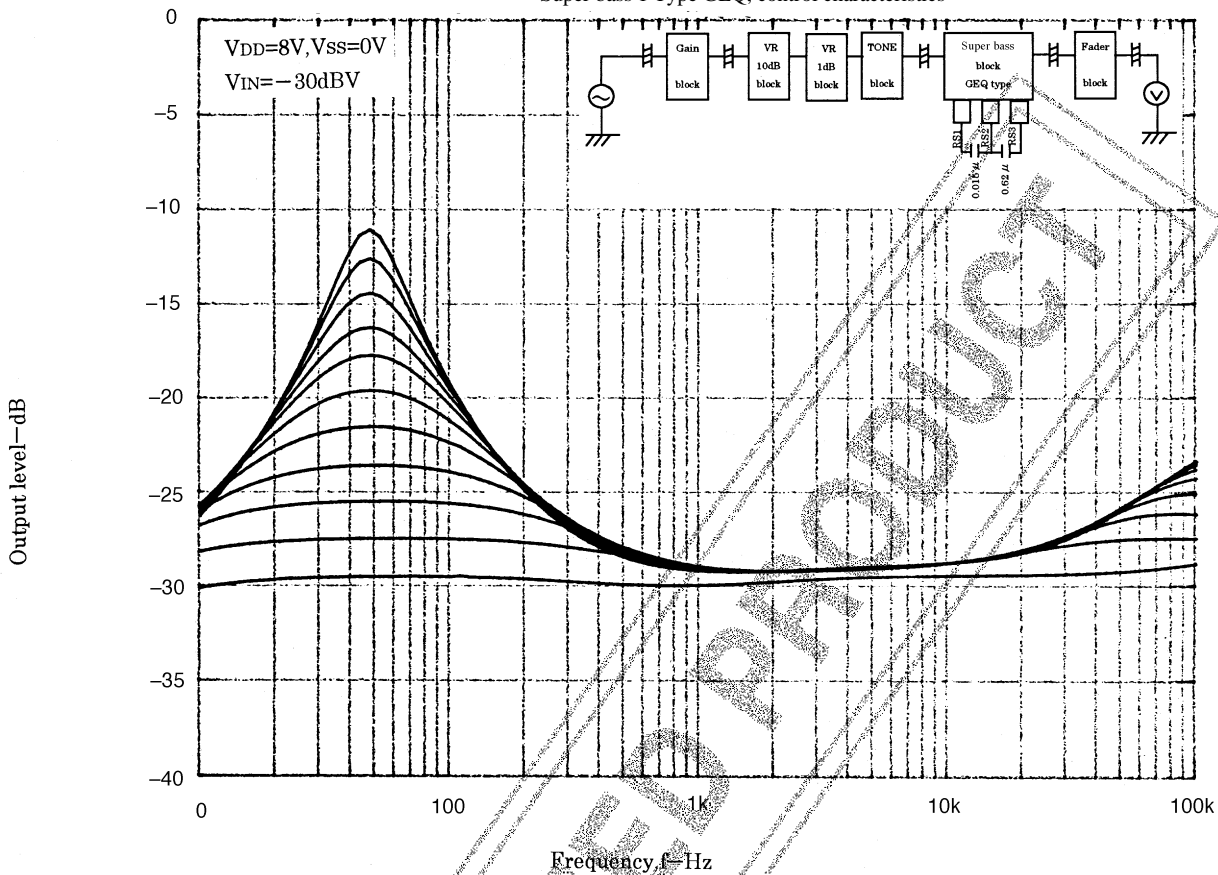
Treble control characteristics



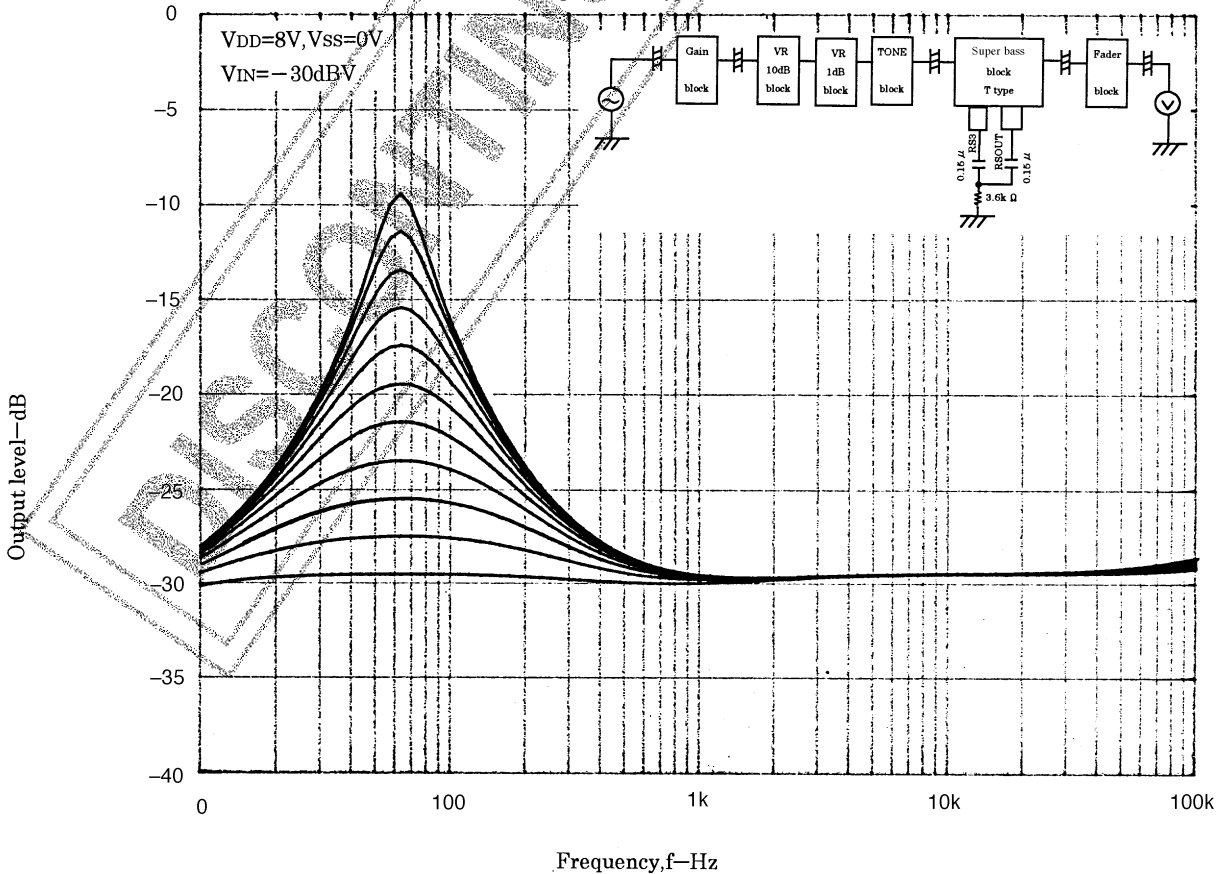
Tone control characteristics



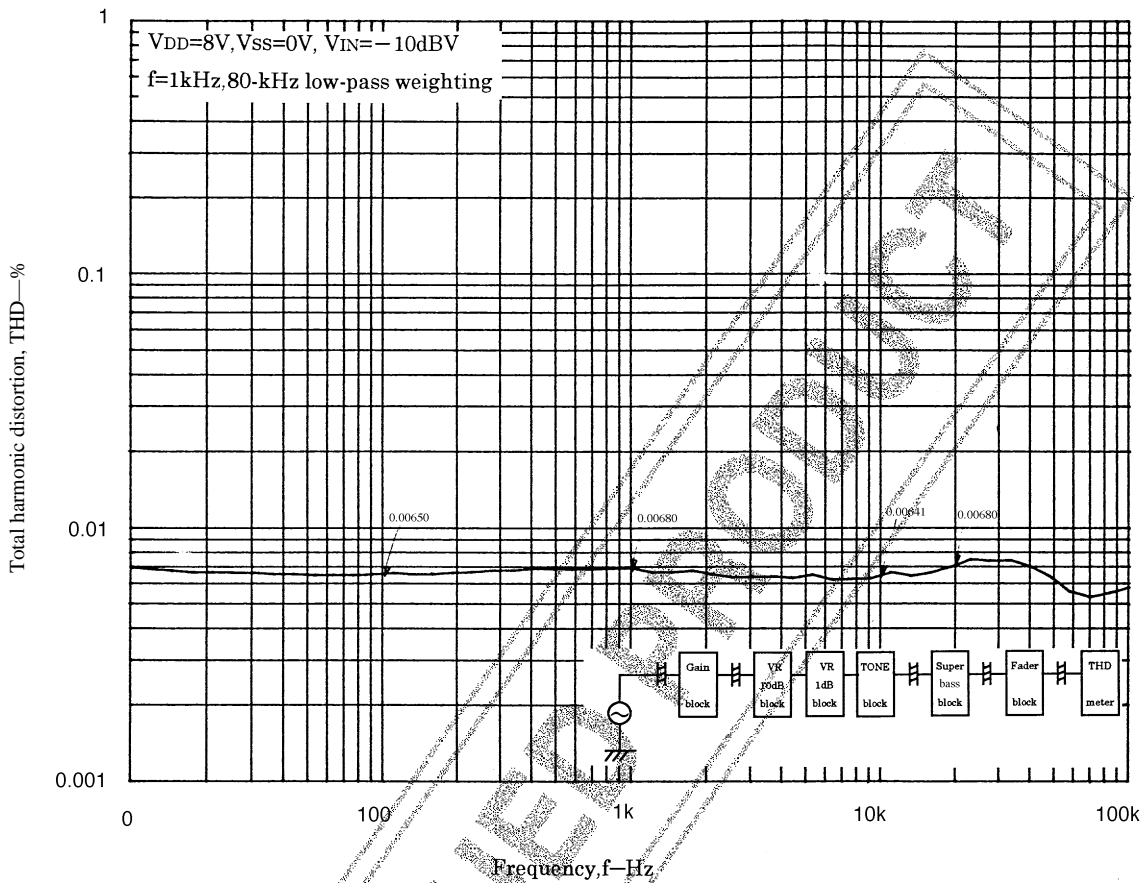
Super bass 1 Type GEQ, control characteristics



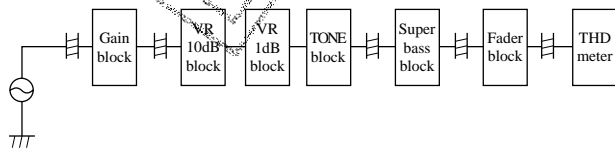
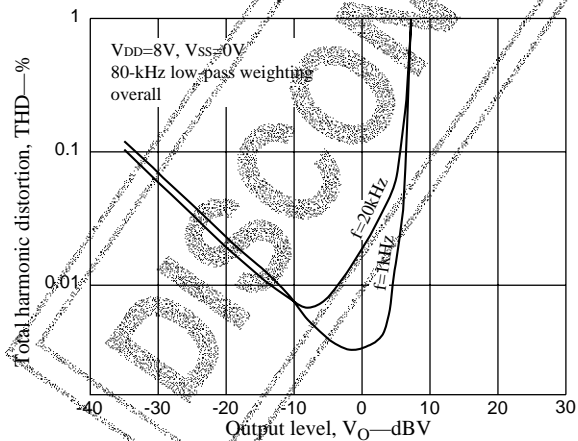
Super bass 2 Type T, control characteristics



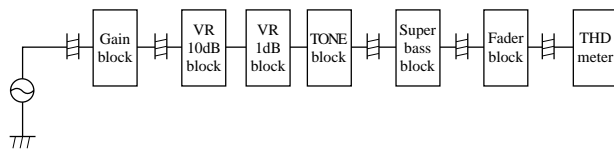
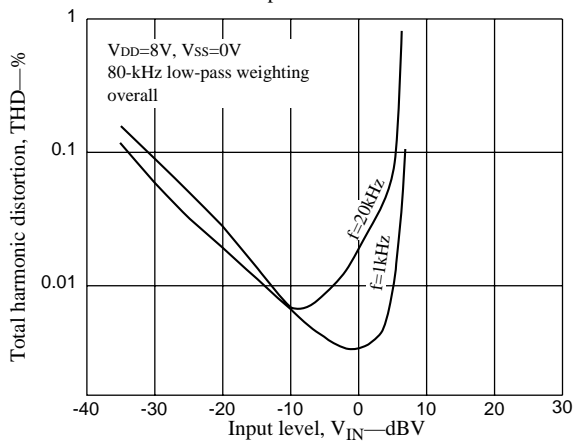
THD—Frequency characteristics



THD—Output level characteristics



THD—Input level characteristics



Usage Notes

1. The states of the internal analog switches are undefined when power is first applied. Use an external muting circuit or other technique to mute the outputs until correct control data has been set up in the LC75373E.
2. Either cover the lines connected to the CL, DI, and CE pins with the ground pattern or use shielded cable for those lines to prevent the high-frequency digital signals on those lines from entering the analog system.

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