



# LC7535M

## Electronic Volume/Loudness Control with Serial Data Control and High Voltage-Handling Capacity



### Overview

The LC7535M is an electronic volume and loudness control IC that provides volume, balance, and loudness functions with a minimal number of external components and that can be controlled electronically.

### 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 volume levels independently.
- Loudness: A loudness function can be implemented by attaching external capacitors at the output tap provided at the -20-dB position in the 5-dB step volume control.
- S (select) pin: Up to two LC7535M chips can be used on the same bus.
- Serial data input: The LC7535M supports communication with the controller in the CCB format.

- 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.

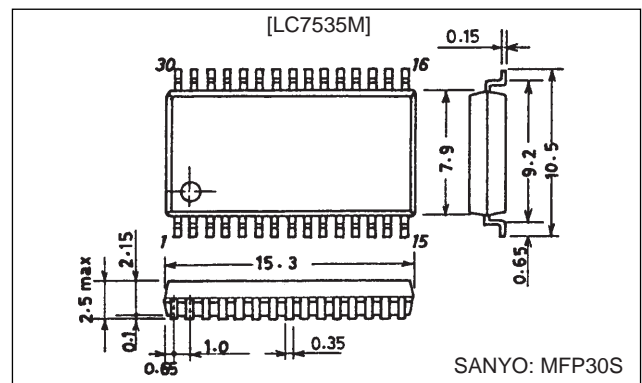
### Feature

- High voltage-handling capacity:  $\pm 16$  V.

### Package Dimensions

unit: mm

#### 3216A-MFP30S



### Specifications

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

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	$V_{DD}$ max	$V_{EE} \leq V_{SS} < V_{CC} < V_{DD}$	$V_{SS}$ to $V_{SS} + 18$	V
	$V_{EE}$ max	$V_{EE} \leq V_{SS} < V_{CC} < V_{DD}$	$V_{SS} - 18$ to $V_{SS}$	V
	$V_{CC}$ max	$V_{EE} \leq V_{SS} < V_{CC} < V_{DD}$	$V_{SS}$ to $V_{SS} + 7$	V
Maximum input voltage	$V_{IN}$ max1	CL, DI, CE	0 to $V_{CC} + 0.3$	V
	$V_{IN}$ max2	L5dBIN, R5dBIN, L1dBIN, R1dBIN	$V_{EE} - 0.3$ to $V_{DD} + 0.3$	V
	$V_{IN}$ max3	S	$V_{CC} - 0.3$ to $V_{DD} + 0.3$	V
Allowable power dissipation	$P_d$ max	$T_a \leq 75^\circ\text{C}$	250	mW
Operating temperature	$T_{opr}$		-30 to +75	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-40 to +125	$^\circ\text{C}$

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

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply voltage	$V_{DD}$	$V_{DD}$	$V_{CC} + 4.5$		16	V
	$V_{EE}$	$V_{EE}$	-16		0	V
	$V_{CC}$	$V_{CC}$	4.5	5	5.5	V
Input high-level voltage	$V_{IH1}$	CL, DI, CE	0.8 $V_{CC}$		$V_{CC}$	V
	$V_{IH2}$	S	$0.8 \times (V_{DD} - V_{CC}) + V_{CC}$		$V_{DD}$	V
Input low-level voltage	$V_{IL1}$	CL, DI, CE	$V_{SS}$		0.2 $V_{CC}$	V
	$V_{IL2}$	S	$V_{CC}$		$0.2 \times (V_{DD} - V_{CC}) + V_{CC}$	V

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# LC7535M

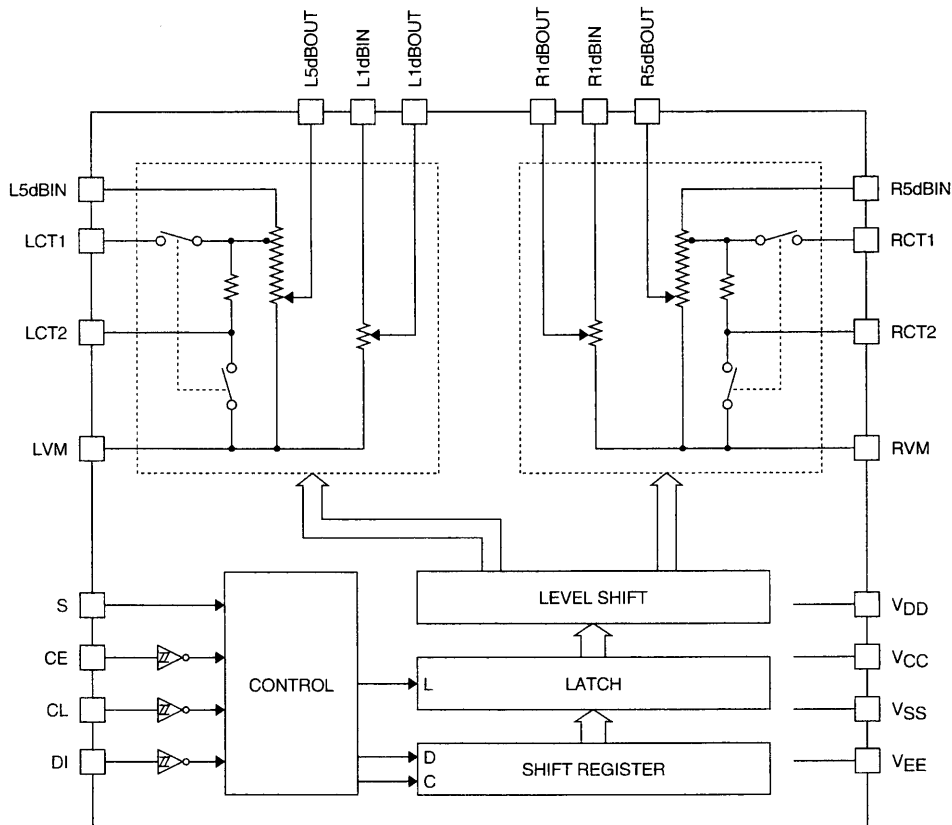
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Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Input voltage amplitude	$V_{IN}$	L5dBIN, R5dBIN, L1dBIN, R1dBIN	$V_{EE}$		$V_{DD}$	Vp-p
Input pulse width	$t_{\text{pw}}$	CL	1			$\mu\text{s}$
Setup time	$t_{\text{set up}}$	CL, DI, CE	1			$\mu\text{s}$
Hold time	$t_{\text{hold}}$	CL, DI, CE	1			$\mu\text{s}$
Operating frequency	$t_{\text{opg}}$	CL			500	kHz

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

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Total harmonic distortion	THD	$V_{IN} = 1\text{ Vrms}$ , $f = 1\text{ kHz}$ , With all tone control settings flat, $V_{DD} - V_{EE} = 30\text{ V}$		0.002		%
Crosstalk	$C_T$	$V_{IN} = 1\text{ Vrms}$ , $f = 1\text{ kHz}$ , With all tone control settings flat, $R_G = 1\text{ k}\Omega$ , $V_{DD} - V_{EE} = 30\text{ V}$		70		dB
Output at maximum attenuation	$V_{Omin}$	$V_{IN} = 1\text{ V rms}$ , $f = 1\text{ kHz}$ , with the volume set at $-\infty$ , $V_{DD} - V_{EE} = 30\text{ V}$		-95		dB
Output noise voltage	$V_N$	With all tone control settings flat, $R_g = 1\text{ k}\Omega$ IHF-A, $V_{DD} - V_{EE} = 30\text{ V}$		2	10	$\mu\text{V}$
Total resistance	Rvol1	5-dB volume control block		75		$\text{k}\Omega$
	Rvol2	1-dB volume control block		20		$\text{k}\Omega$
Output off leakage current	$I_{OFF}$	L5dBIN, R5dBIN, LCT1, RCT1, LCT2, RCT2, L5dBOUT, R5dBOUT, L1dBIN, R1dBIN, L1dBOUT, R1dBOUT, LVM, RVM	-10		+10	$\mu\text{A}$
Input high-level current	$I_{IH}$	CL, DI, CE : $V_{IN} = V_{CC}$			10	$\mu\text{A}$
Input low-level current	$I_{IL}$	CL, DI, CE : $V_{IN} = V_{SS}$	-10			$\mu\text{A}$
Current drain	$I_{DD}$	$V_{DD} = 16\text{ V}$			1	mA
	$I_{CC}$	$V_{CC} = 5.5\text{ V}$			1	mA

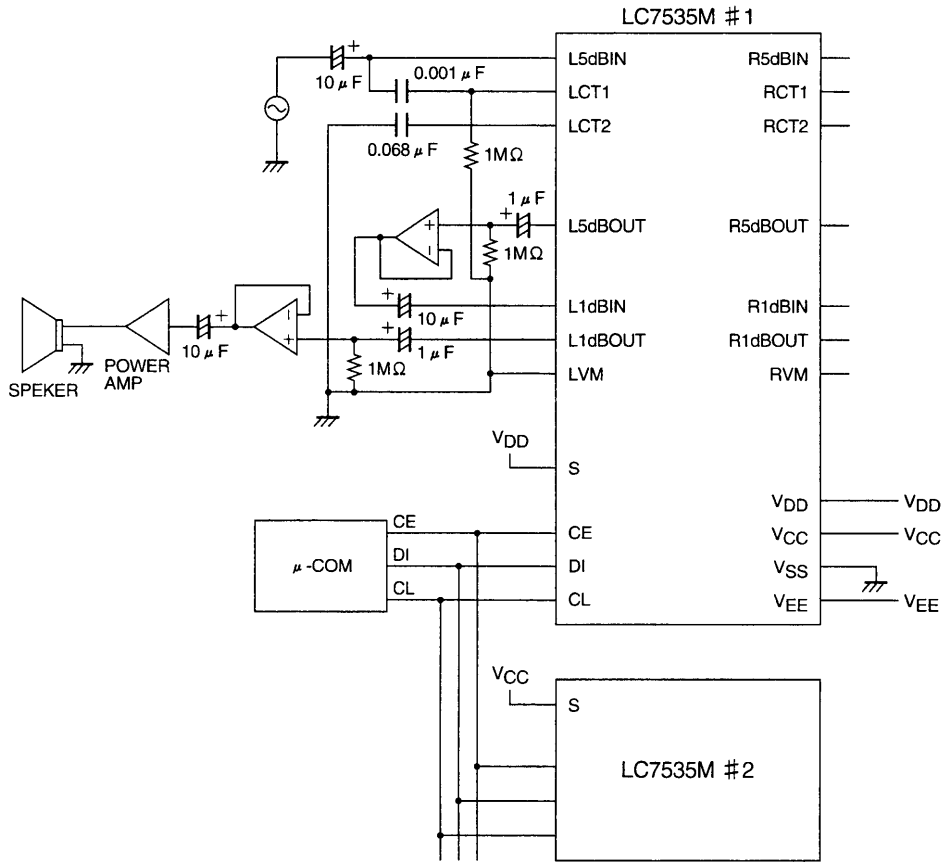
## Equivalent Circuit



A08915

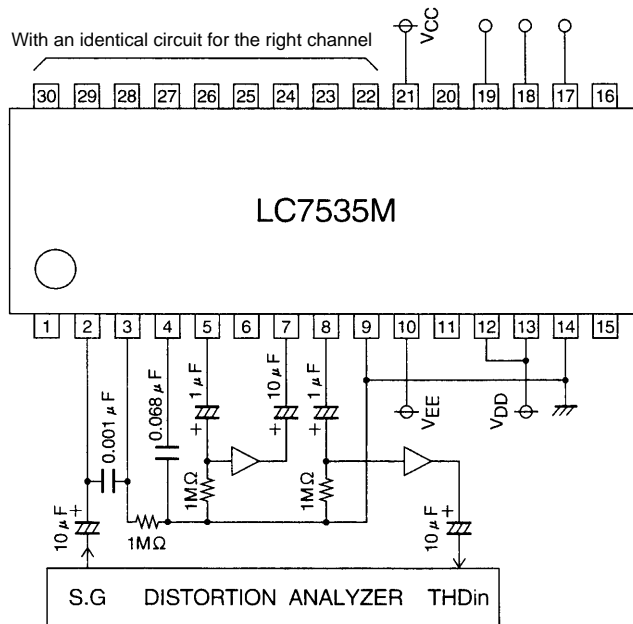
# LC7535M

## Sample Application Circuit



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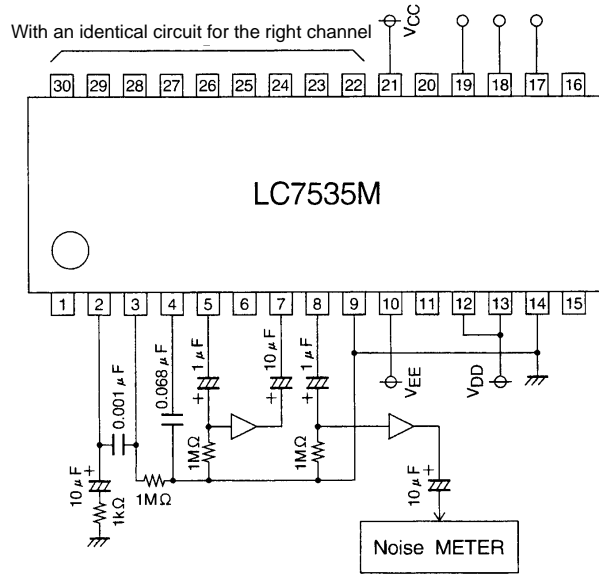
## Test Circuit Total Harmonic Distortion



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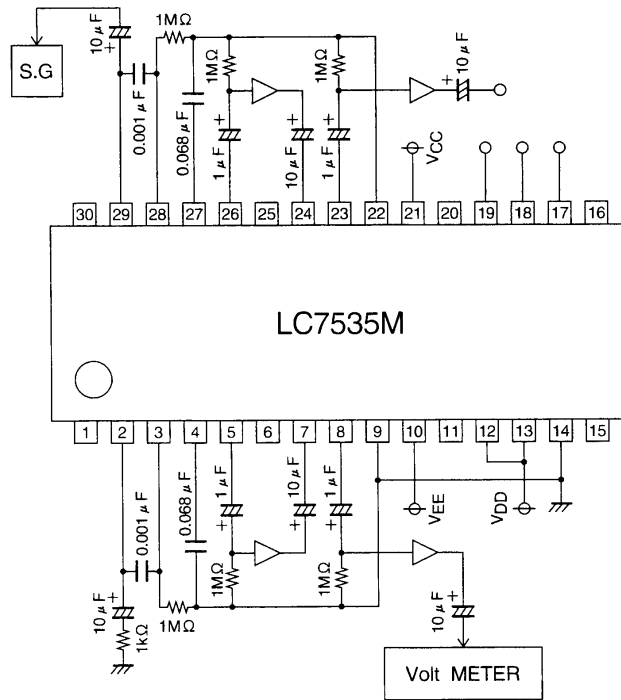
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## Output Noise Voltage



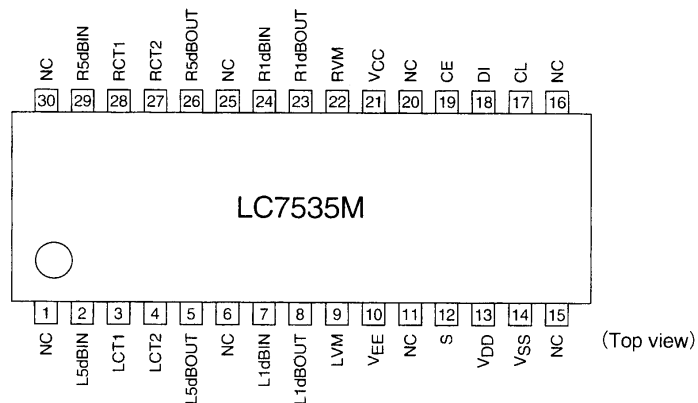
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## Crosstalk



A08919

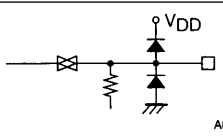
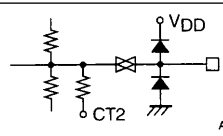
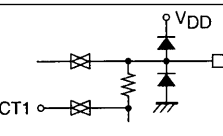
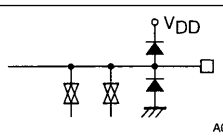
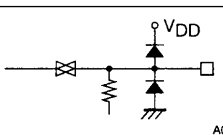
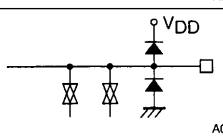
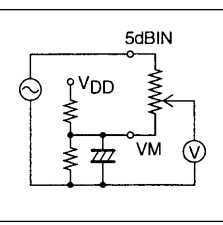
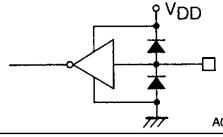
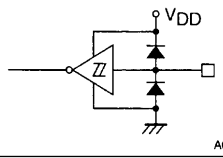
## Pin Assignment



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# LC7535M

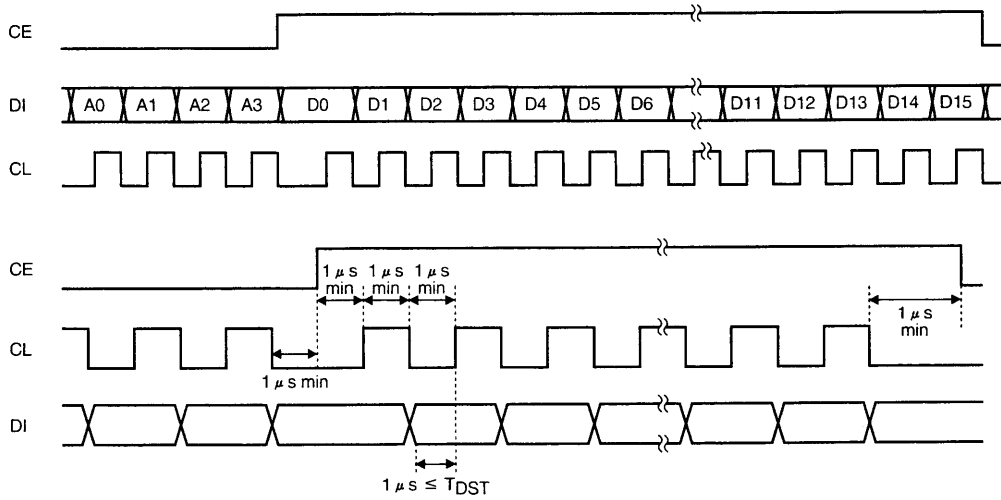
## Pin Descriptions

Pin No.	Pin	Function	Equivalent circuit
2	L5dBIN	<ul style="list-style-type: none"> <li>5-dB step attenuator inputs</li> <li>These inputs must be driven by low-impedance circuits.</li> </ul>	 <p style="text-align: right;">A08921</p>
29	R5dBIN		
3	LCT1	<ul style="list-style-type: none"> <li>Loudness circuit connections</li> <li>Connect the high-band compensation capacitors between the CT1 and 5dBIN pins, and connect the low band compensation capacitors between the CT2 and the V<sub>M</sub> pins.</li> </ul>	 <p style="text-align: right;">A08922</p>
28	RCT1		
4	LCT2		 <p style="text-align: right;">A08923</p>
27	RCT2		
5	L5dBOUT	<ul style="list-style-type: none"> <li>5-dB step attenuator outputs</li> <li>These outputs must be accepted by circuits with an impedance of between 47 kΩ and 1 MΩ.</li> </ul>	 <p style="text-align: right;">A08924</p>
26	R5dBOUT		
7	L1dBIN	<ul style="list-style-type: none"> <li>1-dB step attenuator inputs</li> <li>These inputs must be driven by low-impedance circuits.</li> </ul>	 <p style="text-align: right;">A08925</p>
24	R1dBIN		
8	L1dBOUT	<ul style="list-style-type: none"> <li>1-dB step attenuator outputs</li> <li>These outputs must be accepted by circuits with an impedance of between 47 kΩ and 1 MΩ.</li> </ul>	 <p style="text-align: right;">A08926</p>
23	R1dBOUT		
9	LV <sub>M</sub>	<ul style="list-style-type: none"> <li>Common connections for the volume control circuit. The impedance of the printed circuit board pattern connected to these pins must be kept as low as possible. Since the LV<sub>M</sub>, RV<sub>M</sub>, and V<sub>SS</sub> pins are not connected internally, they must be connected externally as required by the various specifications. When a single-sided power supply is used, the capacitors between V<sub>M</sub> and V<sub>SS</sub> become the residual resistance when the volume control is set at its maximum attenuation. This means that care is required in selecting the values of these capacitors.</li> </ul>	 <p style="text-align: right;">A08927</p>
22	RV <sub>M</sub>		
12	S	<ul style="list-style-type: none"> <li>Selection input for the address code in the data format. If this pin is connected to V<sub>DD</sub>, data will be accepted when the address code is 9, and if connected to V<sub>CC</sub>, data will be accepted when the address code is 8.</li> </ul>	 <p style="text-align: right;">A08928</p>
17	CL	<ul style="list-style-type: none"> <li>Input pins for the serial data used to control the device.</li> <li>These inputs must have an amplitude of 0 to 5 V. In applications in which any of microcontroller CL, DI, or CE may go high in backup mode (when V<sub>DD</sub> = V<sub>CC</sub> = 0 V), the signal lines must have series resistors of at least 2 kΩ inserted.</li> </ul>	 <p style="text-align: right;">A08929</p>
18	DI		
19	CE		
10	V <sub>EE</sub>	<ul style="list-style-type: none"> <li>Power supply connections. All these pins must be connected to the corresponding power supply voltage. When power is first applied, the V<sub>CC</sub> voltage must not rise before V<sub>DD</sub>.</li> </ul>	
13	V <sub>DD</sub>		
14	V <sub>SS</sub>		
21	V <sub>CC</sub>		
1, 6, 11, 15, 16, 20, 25, 30	NC	<ul style="list-style-type: none"> <li>Unconnected (NC) pins</li> <li>Do not connect any signals or devices to these pins.</li> </ul>	

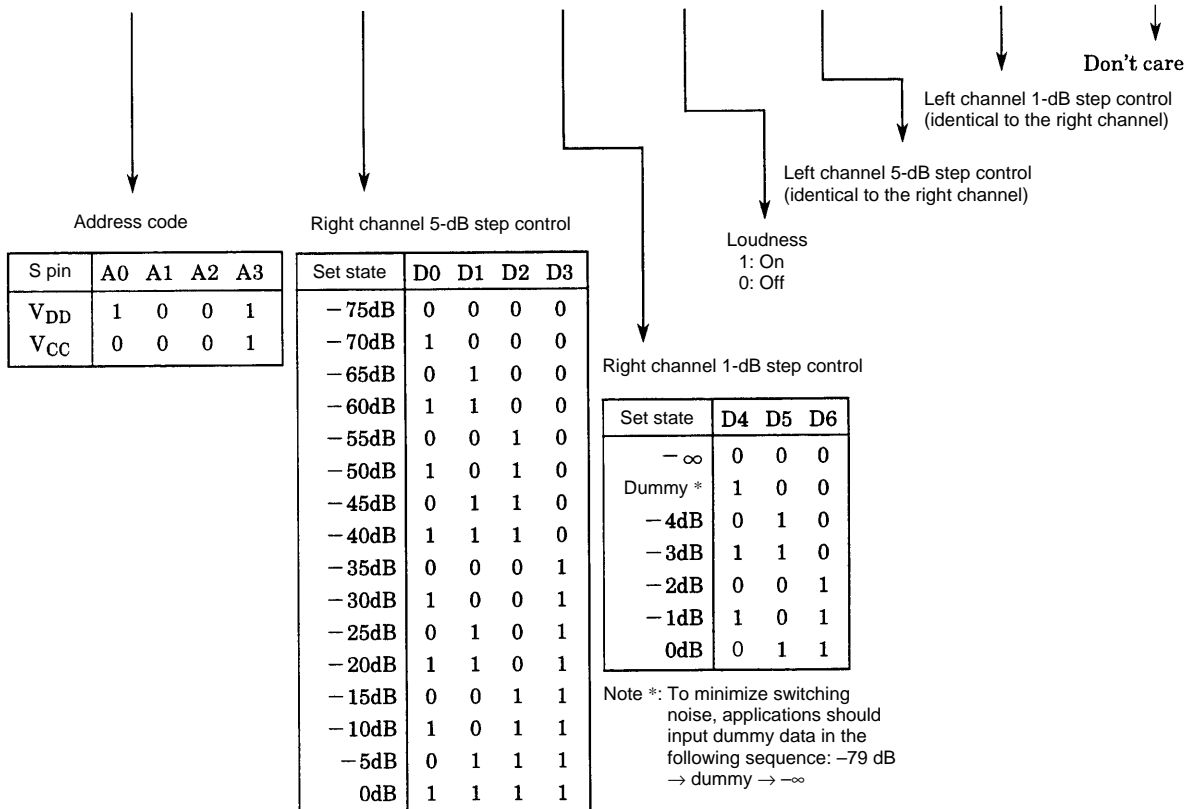
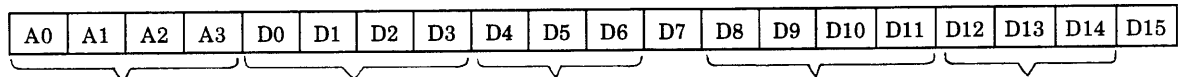
# LC7535M

## Control System Timing and Data Format

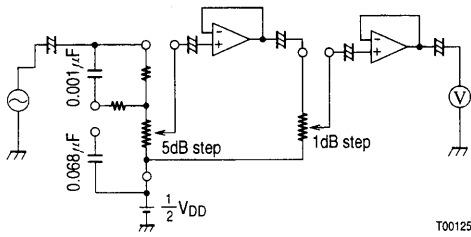
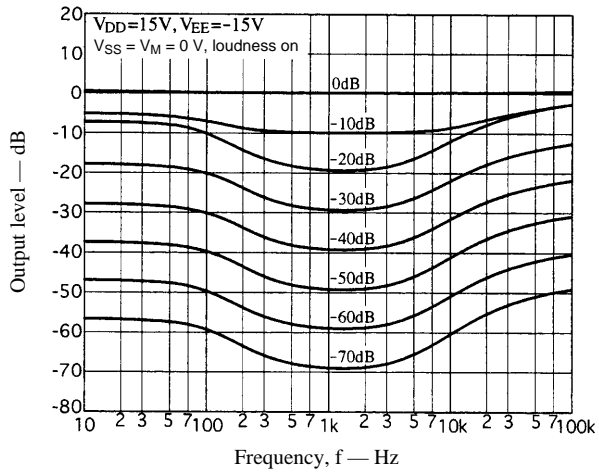
The stipulated serial data must be input to the CL, DI, and CE pins to control the LC7535M. The data consists of a total of 20 bits, of which 4 bits are address and 16 bits are data.



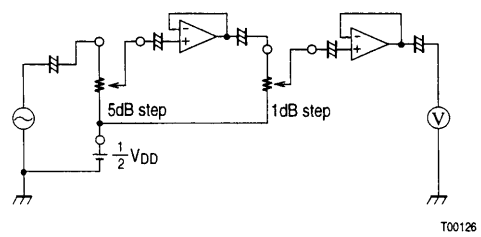
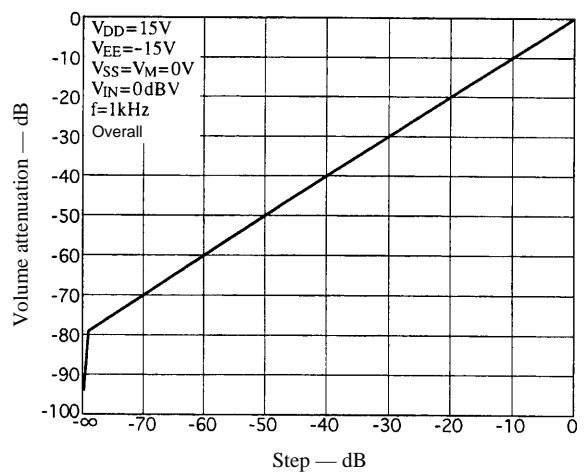
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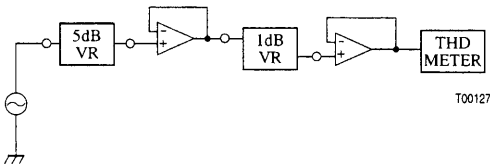
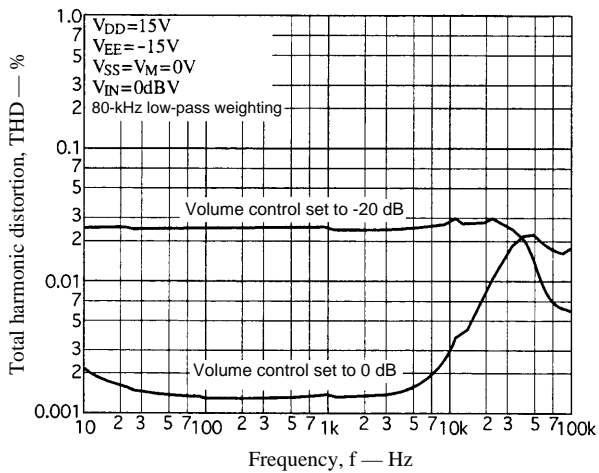
Loudness Characteristics



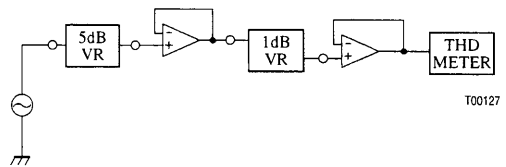
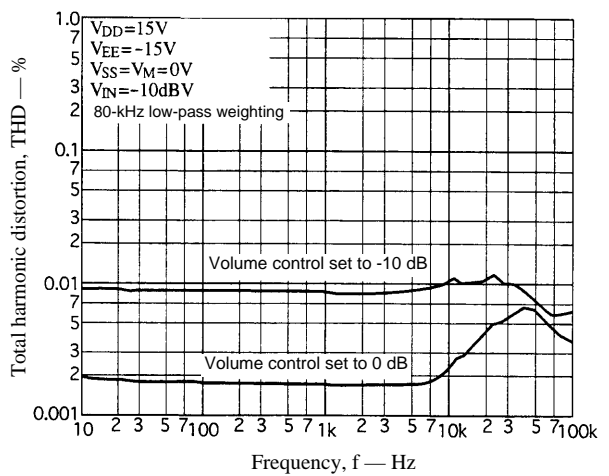
Volume Step Characteristics



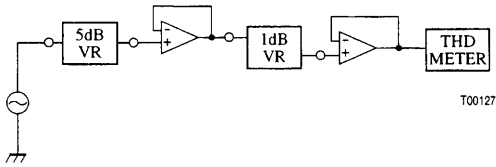
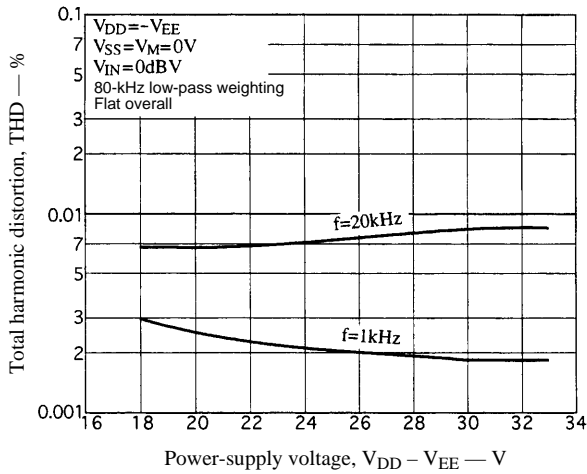
THD – Frequency Characteristics (1)



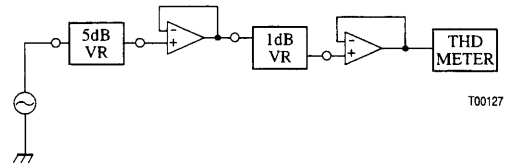
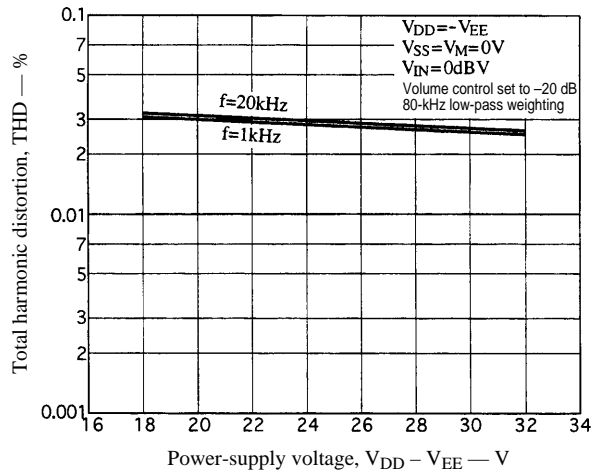
THD – Frequency Characteristics (2)



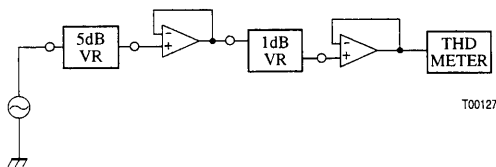
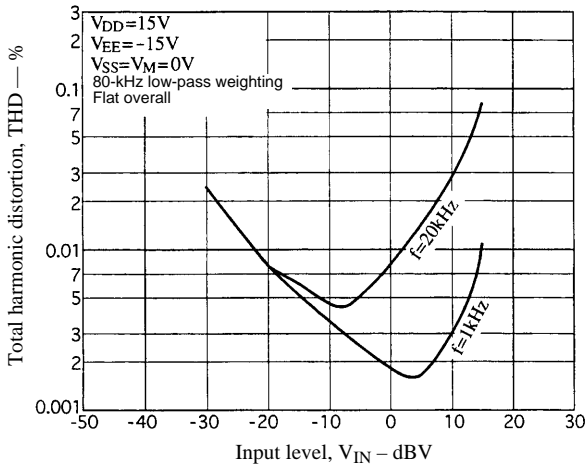
THD – Power-Supply Voltage Characteristics (1)



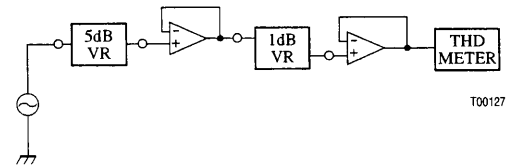
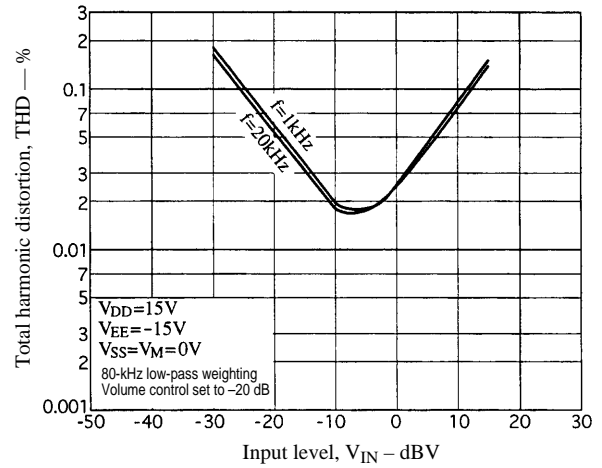
THD – Power-Supply Voltage Characteristics (2)



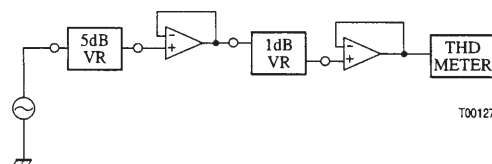
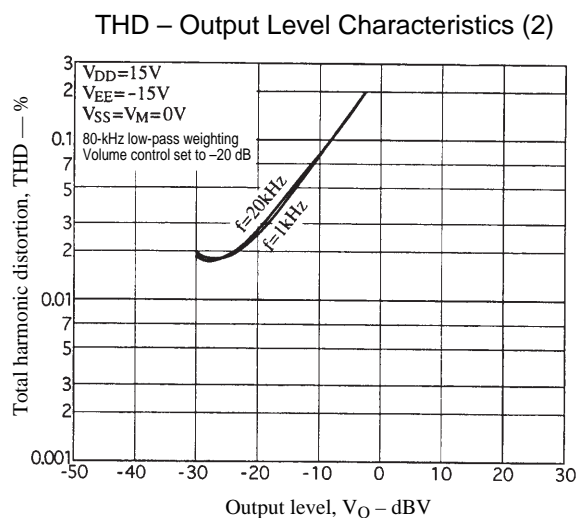
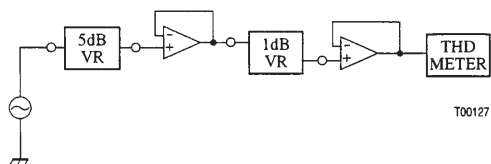
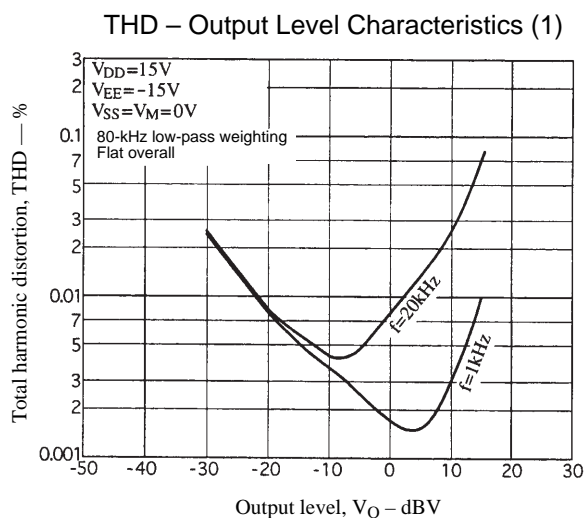
THD – Input Level Characteristics (1)



THD – Input Level Characteristics (2)







**Usage Notes**

- The state of the internal analog switches are undefined when power is first applied. Applications should apply external muting to the output signal until the control data has been set up.
- To prevent the high-frequency digital signals transmitted over the CL, DI, and CE pin lines from entering the analog signal system, these lines should either be covered by the ground pattern or shielded cables should be used.

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