

CMOS IC

LC75421M

Electronic Volume Controller for Cars



Overview

The LC75421M is an electronic volume controller that enables control of volume, balance, fader, bass/treble + super bass, input switching, and input and output level control functions using only a small number of external components.

Functions

- Volume: 0 dB to -79 dB in 1-dB steps, and -∞ (81 positions) Balance function with separate L/R control
- Fader: rear output or front output can be attenuated across 16 positions (in 2-dB steps from 0 dB to -20 dB, 5-dB steps from -20 dB to -25 dB, 10-dB steps from -25 dB to -45 dB, and -60 dB, -∞)
- Bass/treble: A tone control circuit can be configured using an external RC, with 15-position control from 0 dB to ±11.9 dB in 1.7-dB steps possible for both bass and treble
- Input gain: 0 dB to +18.75 dB (1.25-dB steps) amplification is possible for the input signal.
- Output gain: Fader output can be selected among 0 dB, +6.5 dB, and +8.5 dB.
- Input switching: Five input signals can be selected for Left and for Right
- Super bass: Step control with 11 positions is possible, with peaking characteristics (type T)

Features

- On-chip buffer amplifier cuts down number of external components
- Low switching noise generated by on-chip switch due to use of silicon gate CMOS process
- On-chip reference voltage circuit for analog ground
- Controls performed with serial input (CCB)

Package Dimensions

unit: mm

3263-MFP36SDJ (375 mil)



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SANYO Electric Co., Ltd. Semiconductor Company TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN **Pin Assignment**



Equivalent Circuit Block Diagram



Specifications Absolute Maximum Ratings at Ta = 25°C, V_{SS} = 0 V

Parameter	Symbol	Conditions	Ratings	Unit	
Maximum supply voltage	V _{DD} max	V _{DD}	11	V	
Maximum input voltage	1/ 2001	CE, DI, CL	–0.3 to 11	N N	
Maximum input voltage	V _{IN} max	Input pins other than CE, DI, CL	V _{SS} – 0.3 to V _{DD} + 0.3	- V	
Allowable power dissipation	Pdmax	Ta \leq 85°C, when mounted on board	550	mW	
Operating temperature	Topr		-40 to +85	°C	
Storage temperature	Tstg		-50 to +125	°C	

Allowable Operating Ranges at Ta=-40 to $+85^{\circ}C,\,V_{SS}=0$ V

Parameter	Symbol Pin Name		Conditions		Ratings		Unit	
Parameter	Symbol	Pin Name	Conditions	min	typ	max	Onic	
Supply voltage	V _{DD}	V _{DD}	V _{DD}			10	V	
Input high-level voltage	V _{IH}	CL, DI, CE		4.0		10	V	
Input low-level voltage	VIL	CL, DI, CE		V _{SS}		1.0	V	
Input amplitude voltage	V _{IN}	CL, DI, CE, LIN, RIN, L1 to L5, R1 to R5, LFIN, RFIN		V _{SS}		V _{DD}	Vp-p	
Input pulse width	tøW	CL		1			μs	
Setup time	tsetup	CL, DI, CE		1			μs	
Hold time	thold	CL, DI, CE		1			μs	
Operating frequency	fopg	CL				500	kHz	

Electrical Characteristics at Ta = 25°C, V_{DD} = 8 V, V_{SS} = 0 V

Parameter	Symbol Pin Name		Conditions			- Unit		
Farameter	Symbol	Fill Name	Conditions	min	typ	max	Unit	
Maximum input gain	Ginmax				+18.75		dB	
Step resolution	Gstep				+1.25		dB	
Input resistance	Rin	L1, L2, L3, L4, L5 R1, R2, R3, R4, R5			50		kΩ	
Clipping level	Vcl	LSELO, RSELO	THD = 1.0%, f = 1 kHz		2.90		Vrms	
Output load resistance	RL	LSELO, RSELO		10			kΩ	

Volume Block

Parameter	Symbol Pin Name		Conditions		Unit		
Falameter			Conditions	min	typ	max	Unit
Input resistance	Rin	LIN, RIN			50		kΩ

Fader Volume Block

Parameter	Symbol Pin Name		Conditions			Unit		
Parameter	Symbol	Pin Name	Conditions	min	typ	max	Unit	
			STEP = 0 dB to -20 dB		2			
Step resolution	ATstep		STEP = $-20 \text{ dB to} -25 \text{ dB}$		5		dB	
			STEP = $-25 \text{ dB to } -45 \text{ dB}$		10			
Step error	ATerr		STEP = 0 dB to -45 dB	-2	0	+2	dB	
Step erfor	ATen		STEP = $-45 \text{ dB to } -60 \text{ dB}$	-3	0	+3	dВ	
Output load resistance	RL			10			kΩ	
Output impedance	R _O	LFOUT, LROUT RFOUT, RROUT	$\label{eq:RL} \begin{split} RL &= 10 \; k\Omega, f = 1 \; kHz \\ V_{IN} &= 1 \; Vrms \end{split}$		46		Ω	

Bass Band Control Block

Parameter	Symbol Pin Name		Conditions		Unit		
Falameter			Conditions	min	typ	max	Unit
Control range	Gbass		MAX. Boost/Cut	±10	±11.9	±14	dB
Step resolution	Estep			1	1.7	3	dB
Internal feedback resistance	Rfeed				56.084		kΩ

Treble Band Control Block

Parameter	Symbol Pin Name		Conditions		Unit		
Falameter			Conditions	min	typ	max	Office
Control range	Gtre		MAX. Boost/Cut	±10	±11.9	±14	dB
Step resolution	Estep			1	1.7	3	dB
Internal feedback resistance	Rfeed				45.084		kΩ

Super Bass Block (Type T)

Parameter	Symbol Pin Name		Conditions		Unit		
Falameter			Conditions	min	typ	max	Onic
Control range	Crange		MAX. Boost		+20		dB
Step resolution	Estep				+2.0		dB
Internal feedback resistance	Rfeed				66.6		kΩ

General

Parameter Svm		Conditions		Ratings			
Falameter	Symbol	Conditions	min	min typ max		Unit	
Total harmonic distortion	THD	V _{IN} = 1 Vrms, f = 1 kHz, flat overall		0.003	0.01	%	
Crosstalk	СТ	V_{IN} = 1 Vrms, f = 1 kHz, flat overall, Rg = 1 k Ω		80.5		dB	
Maximum attenuated output	Vomin	V_{IN} = 1 Vrms, f = 1 kHz, main volume $-\infty$		-80		dB	
	VN-1	Fflat overall, (IHF-A), RG = 1 k Ω		8		μV	
Output noise voltage	VN-2	Flat overall, (DIN-AUDIO), RG = 1 k Ω		10		μV	
Input high-level current	IIH	CL, DI, CE V _{IN} = 8 V			10	μA	
Input low-level current	IIL	CL, DI, CE V _{IN} = 0 V	-10			μΑ	

Control Timing and Data Format

To control the LC75421M, input specified serial data to the CE, CL, and DI pins. The data configuration consists of a total of 52 bits broken down into 8 address bits and 44 data bits.



Volume Control

D16	D17	D18	D19	D20	D21	D22	D23	Operation
0	0	1	0	0	1	0	1	0dB
1	1	0	0	0	1	0	1	–1dB
0	1	0	0	0	1	0	1	–2dB
1	0	0	0	0	1	0	1	–3dB
0	0	1	1	1	0	0	1	–4dB
1	1	0	1	1	0	0	1	–5dB
0	1	0	1	1	0	0	1	–6dB
1	0	0	1	1	0	0	1	–7dB
0	0	1	0	1	0	0	1	–8dB
1	1	0	0	1	0	0	1	–9dB
0	1	0	0	1	0	0	1	-10dB
1	0	0	0	1	0	0	1	-11dB
0	0	1	1	0	0	0	1	-12dB
1	1	0	1	0	0	0	1	-13dB
0	1	0	1	0	0	0	1	-14dB
1	0	0	1	0	0	0	1	-15dB
0	0	1	0	0	0	0	1	-16dB
1	1	0	0	0	0	0	1	-17dB
0	1	0	0	0	0	0	1	-18dB
1	0	0	0	0	0	0	1	-19dB
0	0	1	1	1	1	1	0	-20dB
1	1	0	1	1	1	1	0	-21dB
0	1	0	1	1	1	1	0	-22dB
1	0	0	1	1	1	1	0	-23dB
0	0	1	0	1	1	1	0	-24dB
1	1	0	0	1	1	1	0	-25dB
0	1	0	0	1	1	1	0	-26dB
1	0	0	0	1	1	1	0	-27dB
0	0	1	1	0	1	1	0	-28dB
1	1	0	1	0	1	1	0	-29dB
0	1	0	1	0	1	1	0	-30dB
1	0	0	1	0	1	1	0	-31dB
0	0	1	0	0	1	1	0	-32dB
1	1	0	0	0	1	1	0	-33dB
0	1	0	0	0	1	1	0	-34dB
1	0	0	0	0	1	1	0	-34dB -35dB
0	0	1	1	1	0	1	0	-35dB -36dB
1	1	0	1	1		1	0	-360B -37dB
			1		0			
0	1	0	1	1	0	1	0	-38dB
1	0	0		1	0	1	0	-39dB
0	0	1	0	1	0	1	0	-40dB
1	1	0	0	1	0	1	0	-41dB
0	1	0	0	1	0	1	0	-42dB
1	0	0	0	1	0	1	0	-43dB
0	0	1	1	0	0	1	0	-44dB
1	1	0	1	0	0	1	0	-45dB
0	1	0	1	0	0	1	0	-46dB
1	0	0	1	0	0	1	0	-47dB
0	0	1	0	0	0	1	0	-48dB
1	1	0	0	0	0	1	0	-49dB
0	1	0	0	0	0	1	0	-50dB

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D16	D17	D18	D19	D20	D21	D22	D23	Operation
1	0	0	0	0	0	1	0	–51dB
0	0	1	1	1	1	0	0	–52dB
1	1	0	1	1	1	0	0	–53dB
0	1	0	1	1	1	0	0	–54dB
1	0	0	1	1	1	0	0	–55dB
0	0	1	0	1	1	0	0	–56dB
1	1	0	0	1	1	0	0	–57dB
0	1	0	0	1	1	0	0	–58dB
1	0	0	0	1	1	0	0	–59dB
0	0	1	1	0	1	0	0	-60dB
1	1	0	1	0	1	0	0	-61dB
0	1	0	1	0	1	0	0	-62dB
1	0	0	1	0	1	0	0	-63dB
0	0	1	0	0	1	0	0	-64dB
1	1	0	0	0	1	0	0	-65dB
0	1	0	0	0	1	0	0	-66dB
1	0	0	0	0	1	0	0	-67dB
0	0	1	1	1	0	0	0	-68dB
1	1	0	1	1	0	0	0	-69dB
0	1	0	1	1	0	0	0	-70dB
1	0	0	1	1	0	0	0	–71dB
0	0	1	0	1	0	0	0	-72dB
1	1	0	0	1	0	0	0	-73dB
0	1	0	0	1	0	0	0	-74dB
1	0	0	0	1	0	0	0	-75dB
0	0	1	1	0	0	0	0	-76dB
1	1	0	1	0	0	0	0	–77dB
0	1	0	1	0	0	0	0	-78dB
1	0	0	1	0	0	0	0	-79dB
0	0	0	0	0	0	0	0	–∞dB

Input Switch Control (L1, L2, L3, L4, L5, R1, R2, R3, R4, R5)

D28	D29	D32	Operation
0	0	1	L1 (R1) ON
1	0	1	L2 (R2) ON
0	1	1	L3 (R3) ON
1	1	1	L4 (R4) ON
0	0	0	L5 (R5) ON

Pin Functions

Pin No.	Pin Name	Function	Equivalent circuit
18	L1		
17	L2		
16	L3		
15	L4		
14	L5		
20	R1	Input signal pins	
	R2		
21			
22	R3		Rn 🔺 🛸 🍈 📕
23	R4		^o Vref ⁷⁷⁷
24	R5		777
13	LSELO	Input selector output pins	
25	RSELO		
10 9 28 29	LBASS1 LBASS2 RBASS1 RBASS2	• Bass band filter configuration capacitor and resistor connection pins	VDD VDD VDD BASS1 WDD WDD WDD WDD WDD WDD WDD WDD WDD WD
8 7 30 31	LSB LOUT RSB ROUT	• Super bass band filter configuration capacitor and resistor connection pins	VDD VDD VDD VDD VDD VDD VDD VDD VDD VDD
5 4 33 34	LFOUT LROUT RFOUT RROUT	 Fader output pins. The front side and rear side can be attenuated separately. The attenuation is the same for both Left and Right. 	VDD

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Pin No.	Pin Name	Function	Equivalent circuit	
11 27	LTRE RTRE	Capacitor connection pin for configuring treble filter		
19	Vref	• Connect a capacitor of a few tens of μF between Vref and AV_{SS} (V_{SS}) as a analog ground 0.5 \times V_{DD} voltage generator, current ripple countermeasure.	VDD Vref 777	
3	V _{SS}	Ground pin		
35	V _{DD}	Power supply pin		
2	CE	• Chip enable pin Data is written to the internal latch and the analog switches are operated when the level changes from High to Low. Data transfer is enabled when the level is High.		
1 36	DI CL	Serial data pin and clock input pin for control		

Equivalent Circuit Input Block Diagram



Same for right channel Unit: (Resistance: Ω)

LIN	Should Blagram		
R1 = 5434 ≤ −1 dB	R28 = 243 ≥	R55 = 87 ≷55 dB	То
R2 = 4845 ≤ −2 dB	R29 = 216	R56 = 77 \$	> Treble Block
R3 = 4319 ≩ −3 dB	R30 = 193	R57 = 69 ≥	
R4 = 3850 -4 dB	R31 = 172	R58 = 61 \$58 dB	
R5 = 3431	R32 = 153	R59 = 55 \$	
R6 = 3058	R33 = 137 -33 dB	R60 = 49	
R7 = 2726	R34 = 122	R61 = 87 ≩61 dB	
R8 = 2429	R35 = 108	R62 = 78 ≥62 dB	
R9 = 2165	R36 = 97 -36 dB	R63 = 69 ≩63 dB	
R10 = 1930	R37 = 86	R64 = 62 ≩	
R11 = 1720	R38 = 77	R65 = 55 ≩65 dB	
R12 = 1533 ≩−12 dB	R39 = 68	R66 = 49 ≩	
R13 = 1366	R40 = 61	R67 = 87 ≩	
R14 = 1218	R41 = 54	R68 = 78 ≩	
R15 = 1085 ≤	R42 = 48	R69 = 69	
R16 = 967 ≤	R43 = 86	R70 = 62	
R17 = 862 ≥	R44 = 77	R71 = 55 ≥	
R18 = 768 ≥	R45 = 69	R72 = 49 ≥	
R19 = 685 ≶	R46 = 61	R73 = 87 ≩	
R20 = 610	R47 = 55	R74 = 78 ≩	
R21 = 544 ≩	R48 = 49 -48 dB	R75 = 69 ≩	
R22 = 485 ≤	R49 = 87	R76 = 62 ≥	
R23 = 432 ≷	R50 = 77	R77 = 55 ≶	
R24 = 385 ≩	R51 = 69	R78 = 49 ≩	
R25 = 343 ≷	R52 = 61	R79 = 44 ₹	
R26 = 306 ≷	R53 = 55 ≩	R80 = 359 ₹ —∞ dB	
R27 = 273 ≷	R54 = 49		
79	↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	800 ≷ ≷ 802 ≷ 804	
R		R84 R85 R86	
	L		
	Same for right channel	 LVref	
	Unit: (Resistance: Ω)		No. 6866 12/2/

Volume Block Equivalent Circuit Diagram



Treble/Bass/Super Bass Band Block Equivalent Circuit Diagram

No. 6866-13/24



Fader Volume Block Equivalent Circuit Diagram

When ----- data is sent to the main volume, S1 and S2 become open, and S3 and S4 simultaneously become ON.

Tone Circuit Constant Calculation Examples

Super Bass Band Circuit

The equivalent circuit and the formula for calculating the external RC with a mean frequency of 68 Hz are shown below.

• Super bass band equivalent circuit block diagram



• Calculation example

Specification Mean frequency: f0 = 68 Hz

Gain during maximum boost: G = 20 dBLet us use R1 = 0, $R2 = 66.6 \text{ k}\Omega$, and C1 = C2 = C.

We obtain R3 from G = 20 dB.

$$G_{+20 \, dB} = 20 \times LOG_{10} \left(1 + \frac{R2}{2R3} \right)$$
$$R3 = \frac{R2}{2 \left(10^{G+20 dB/20} - 1 \right)} = \frac{666000}{2 \times (10 - 1)} \neq 3.7 \, K\Omega$$

We obtain C from mean frequency f0 = 68 Hz.

$$f0 = \frac{1}{2\pi\sqrt{R3R2C1C2}}$$
$$C = \frac{1}{2\pi/0\sqrt{R3R2}} = \frac{1}{2\pi\times68\sqrt{66600\times3700}} \neq 0.15 \,\mu F$$

We obtain Q.

$$Q = \frac{R3R2}{2R3} \frac{1}{\sqrt{R3R2}} \neq 2.1$$

Treble Band Circuit

The shelving characteristics can be obtained for the treble band.

The equivalent circuit and calculation formula during boost are indicated below.



• Calculation example 1

Specification Set frequency: f = 10000 Hz

Gain during maximum boost: $G_{+14 \text{ dB}} = 14 \text{ dB}$

Let us use $R1 = 11.030 \text{ k}\Omega$ and $R2 = 45.054 \text{ k}\Omega$.

The above constants are inserted in the following formula.

$$G = 20 \times LOG_{10} \left(1 + \frac{R2}{\sqrt{R1^2 + (1 / \omega C)^2}} \right)$$
$$C = \frac{1}{2\pi f \sqrt{(\frac{R2}{10^{G/20} - 1})^2 - R1^2}}$$
$$= \frac{1}{2\pi 10000 \sqrt{(\frac{45054}{5.01 - 1})^2 - 11030^2}} \neq 6800(pF)$$

Setting	f = 10 kHz	f = 1 kHz
14 dB	13.95	7.42
12 dB	11.98	6.96
10 dB	10	6.34
8 dB	8	5.5
6 dB	6	4.43
4 dB	4	3.13
2 dB	2	1.64

• Calculation example 2

Specification Set frequency: f = 10000 Hz

Gain during maximum boost: $G_{+11.9 \text{ dB}} = 11.9 \text{ dB}$ Let us use $R1 = 11.030 \text{ k}\Omega$ and $R2 = 45.054 \text{ k}\Omega$. The above constants are inserted in the following formula.

$$G = 20 \times LOG_{10} \left(1 + \frac{R2}{\sqrt{R1^2 + (1 / \omega C)^2}} \right)$$
$$C = \frac{1}{2\pi f \sqrt{(\frac{R2}{10^{11.9/20} - 1})^2 - R1^2}}$$
$$= \frac{1}{2\pi 10000 \sqrt{(\frac{45054}{3.94 - 1})^2 - 11030^2}} \neq 1500(pF)$$

Setting	f = 10 kHz	f = 1 kHz
11.9 dB	11.92	0.00
10.2 dB	10.64	0.00
8.5 dB	9.17	0.00
6.8 dB	7.52	0.00
5.1 dB	5.74	0.00
3.4 dB	3.88	0.00
1.7 dB	1.96	0.00

Bass Shelving Circuit

- The equivalent circuit and calculation formula during boost are shown below.
- Bass band equivalent circuit diagram



• Calculation example 1

Specification Mean frequency:
$$f0 = 40$$
 Hz

Gain during maximum boost: $G_{+14 \text{ dB}} = 14 \text{ dB}$ Let us use $R1 = 0 \text{ k}\Omega$, $R2 = 45.054 \text{ k}\Omega$, $C1 = 2.2 \mu\text{F}$, and C1 >> C2.

We obtain R3 from G = 14 dB.

$$G_{+14\,dB} = 20 \times LOG_{10} \left(\frac{R2 + R3}{R3}\right)$$
$$R3 = \frac{R2}{10^{G/20} - 1} = \frac{45054}{5.01 - 1} \neq 11 \ K\Omega$$

We obtain C2 from mean frequency f0 = 40 Hz.

$$f0 = \frac{1}{2\pi\sqrt{R3R2C1C2}}$$

$$C2 = \frac{1}{(2\pi f0)^2 R2R3C1} = \frac{1}{(2\pi \times 40)^2 \times 45054 \times 11000 \times (2.2 \times 10^{-6})} \neq 0.015 \,\mu F$$

Setting	f = 100 Hz	f = 1 kHz
14 dB	13.55	3.65
12 dB	11.73	3.51
10 dB	9.8	3.31
8 dB	7.89	3
6 dB	5.94	2.55
4 dB	3.97	1.92
2 dB	1.99	1.07

• Calculation example 2

Specification Mean frequency: f0 = 40 Hz

Gain during maximum boost: G = 12 dBLet us use $R1 = 0 \text{ k}\Omega$, $R2 = 45.054 \text{ k}\Omega$, C1 = 2.2 uF, and C1 >> C2.

We obtain R3 from G = 12 dB.

$$G_{+12 \, dB} = 20 \times LOG_{10} \left(\frac{R2 + R3}{R3} \right)$$
$$R3 = \frac{R2}{10^{G/20} - 1} = \frac{45054}{3.98 - 1} \neq 15 \, K\Omega$$

We obtain C2 from mean frequency f0 = 40 Hz.

$$f 0 = \frac{1}{2\pi\sqrt{R3R2C1C2}}$$

$$C2 = \frac{1}{(2\pi/0)^2 R2R3C1} = \frac{1}{(2\pi \times 40)^2 \times 45054 \times 15000 \times (2.2 \times 10^{-6})} \neq 0.01 \ \mu F$$

Setting	f = 100 Hz	f = 1 kHz
14 dB	11.73	4.27
12 dB	10.29	4.07
10 dB	8.74	3.78
8 dB	7.11	3.38
6 dB	5.41	2.82
4 dB	3.65	2.09
2 dB	1.85	1.15

(4) Bass Peaking Circuit

The equivalent circuit and the formula for calculating the external RC with a mean frequency of 100 Hz are shown below.

• Bass band equivalent circuit diagram



• Calculation example

Specification Mean frequency: f0 = 100 Hz

Gain during maximum boost: G = 11.9 dBLet us use R1 = 0, $R2 = 45.084 \text{ k}\Omega$, and C1 = C2 = C.

We obtain R3 from G = 11.9 dB.

$$G_{+11.9\,dB} = 20 \times LOG_{10} \left(1 + \frac{R2}{2R3} \right)$$
$$R3 = \frac{R2}{2\left(10^{11.9dB/20} - 1 \right)} = \frac{45084}{2 \times (3.936 - 1)} \neq 7.68 \ K\Omega$$

We obtain C from mean frequency f0 = 100 Hz.

$$f 0 = \frac{1}{2\pi\sqrt{R3R2C1C2}}$$
$$C = \frac{1}{2\pi f_0 \sqrt{R3R2}} = \frac{1}{2\pi \times 100 \sqrt{45084 \times 7680}} \neq 0.082 \,\mu F$$

We obtain Q.

$$Q = \frac{R3R2}{2R3} \bullet \frac{1}{\sqrt{R3R2}} \neq 1.66$$

Setting	f = 100 Hz	f = 1 kHz
11.9 dB	11.88	0.00
10.2 dB	10.38	0.00
8.5 dB	8.79	0.00
6.8 dB	7.14	0.00
5.1 dB	5.42	0.00
3.4 dB	3.66	0.00
1.7 dB	1.85	0.00

Usage Cautions

- (1) Upon power application, the internal analog switch status is undefined. Use an external countermeasure such as muting until data is set.
- (2) When performing initial data setting after applying power, send the initial data once, and then send the initial setting data.
- (3) To ensure that the digital frequency signal sent to the CL, DI, and CE pins do not spill over to the analog signal block, either guard these signal lines with a ground pattern, or perform transmission using shielded wires.





















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