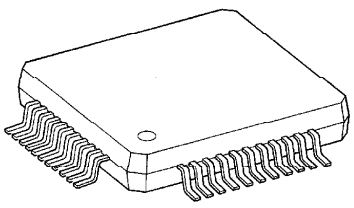
TOSHIBA CMOS DIGITAL INTEGRATED CIRCUIT SILICON MONOLITHIC

TC9421F

SYSTEM ELECTRONIC VOLUME

TC9421F is a single-chip electronic volume IC incorporating an op amp circuit developed for car stereos.
With a few external parts, TC9421F can control a wide range of audio functions, including main volume, balance, fader, bass, treble, loudness, and input switching.



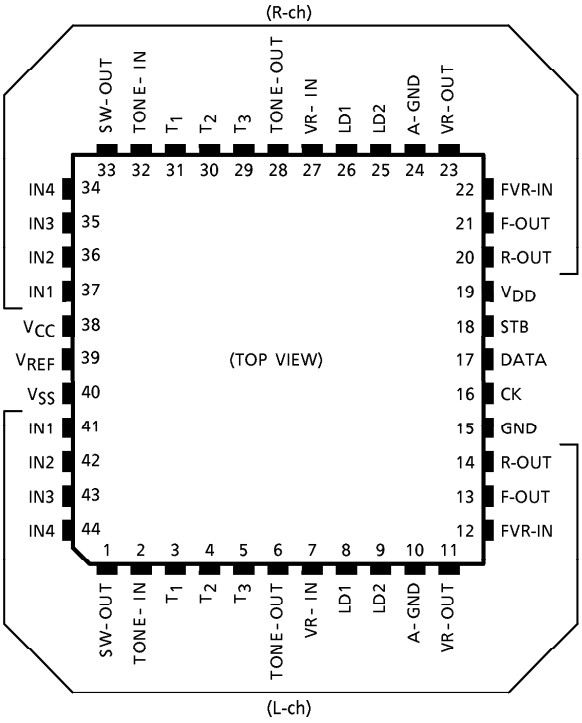
QFP44-P-1414-0.80D

Weight : 1.1g (Typ.)

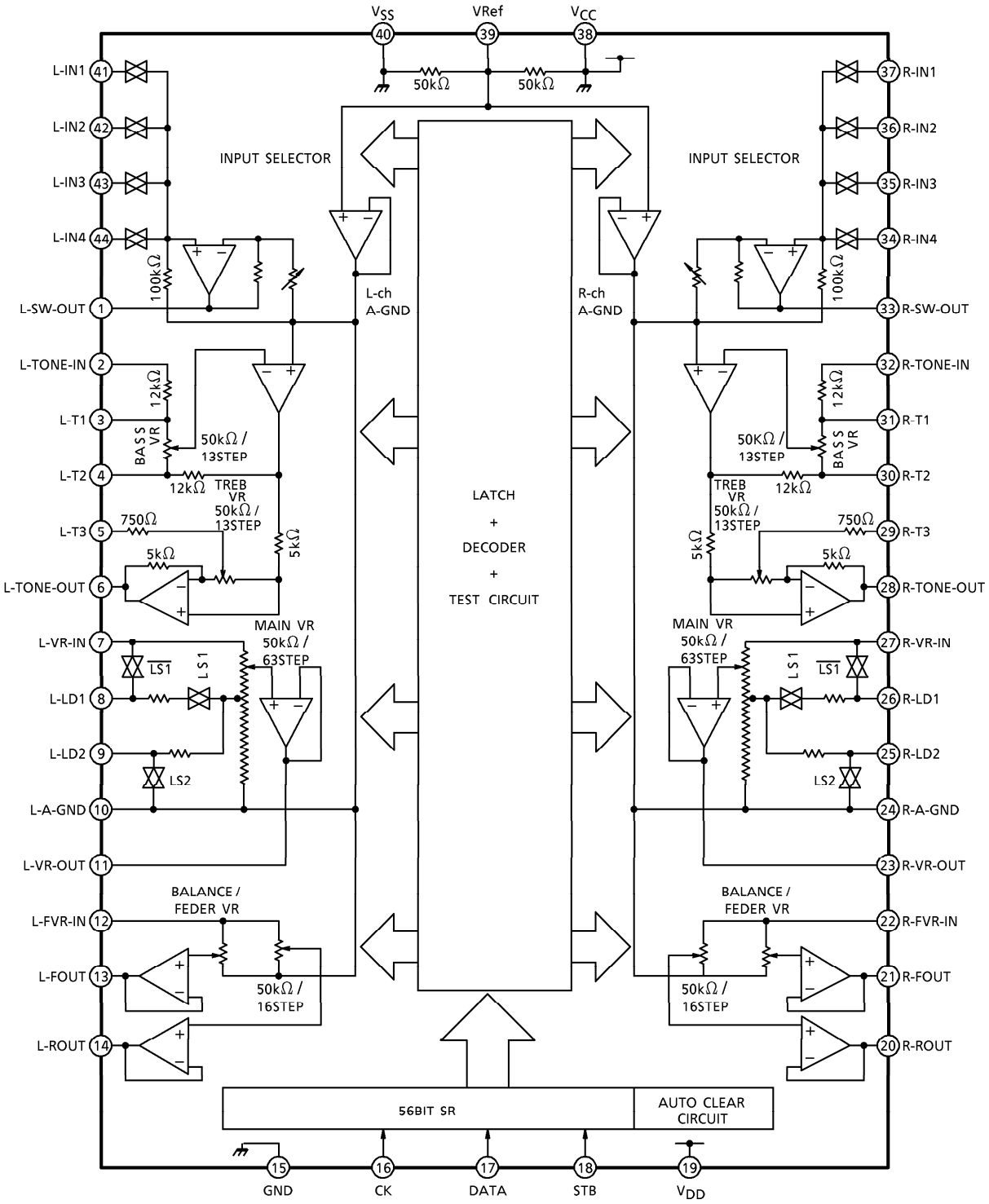
FEATURES

- Main volume : Offers 63 positions of separate left and right control over the range 0~78dB and ∞ (in 1~2dB / steps).
- Fader volume : Incorporates four sets of front (left and right) and rear (left and right) fader units for a range of 0~60dB and ∞ (16 positions)
- Tone control : ±12dB for both bass and treble (13 positions)
- Input selector : Any of four input signals can be amplified with any of four gain options : 0, 6, 10, or 12dB
- Incorporates op amp circuit, reducing external parts.
- Incorporates an interface for a 5V-system microcomputer.
- The Si-gate process realizes a high-performance volume system.

PIN CONNECTION



BLOCK DIAGRAM



DESCRIPTION OF PINS

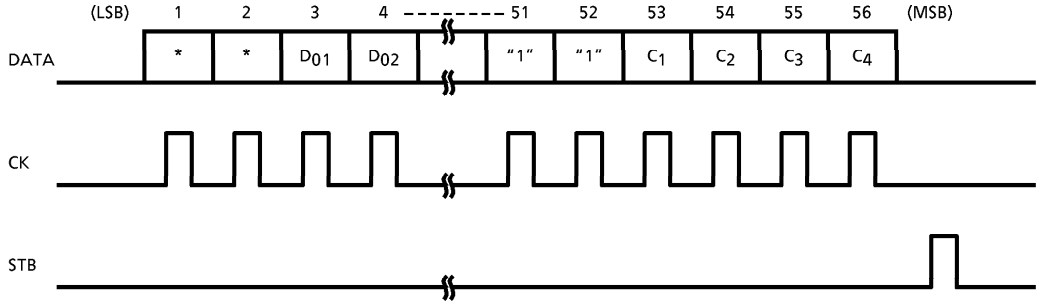
PIN No.	SYMBOL	PIN NAME	FUNCTION AND OPERATION	REMARKS
41	L-IN1	Audio signal input pins	• Four input selector circuits • Input switches can be controlled independently • Op amp circuit gain can be set to 0dB, 6dB, 10dB, or 12dB	—
42	L-IN2			
43	L-IN3			
44	L-IN4			
37	R-IN1			
36	R-IN2			
35	R-IN3			
34	R-IN4			
1	L-SW-OUT	Input selector output pins		
33	R-SW-OUT			
2	L-TONE-IN	Tone circuit input pins	• Tone control circuit • Insert bass control capacitor between T_1 and T_2 • Insert treble control capacitor between T_1 (T_2) and T_3 • Supports 13-position control (±12dB Typ.)	—
32	R-TONE-IN			
3	L-T_1	Capacitor connection pins		
4	L-T_2			
5	L-T_3			
31	R-T_1			
30	R-T_2			
29	R-T_3			
6	L-TONE-OUT	Tone circuit output pins		
28	R-TONE-OUT			
7	L-VR-IN	Main volume input pins	• Main volume circuit • 63-position control : 0~44dB (1dB / steps), 44~78dB (2dB / steps) and ∞ • Balance control based on independent control of left and right channels • Loudness control enabled by connecting capacitor to LD1 and LD2	—
27	R-VR-IN			
8	L-LD1	Loudness pins		
9	L-LD2			
26	R-LD1			
25	R-LD2			
11	L-VR-OUT	Main volume output pins		
23	R-VR-OUT			
10	L-A-GND	Analog ground pins	• Internal op amp reference voltage pins • Insert capacitor between these pins and GND	—
24	R-A-GND			
12	L-FVR-IN	Fader volume input pins	• Fader volume circuit • 16-position control from 0~60dB and ∞ • Sound volume can be controlled individually for left front, left rear, right front, and right rear	—
22	R-FVR-IN			
13	L-F-OUT	Front output pins		
21	R-F-OUT			
14	L-R-OUT	Rear output pins		
20	R-R-OUT			

PIN No.	SYMBOL	PIN NAME	FUNCTION AND OPERATION	REMARKS
16	CK	Clock input pin	• Serial data transfer clock input pin	Low threshold value input pins
17	DATA	Data input pin	• Control data input pin	
18	STB	Strobe input pin	• Data write strobe input pin	
38	V_{CC}	Analog power supply pin	• Use with $V_{CC} = V_{DD}$	—
19	V_{DD}	Digital power supply pin		
40	V_{SS}	Analog ground pin	• Ground pins	
15	GND	Digital ground pin		
39	V_{REF}	Reference voltage input pin	• Used to determine internal op amp reference voltage (A-GND) • Incorporates resistor for dividing voltage between V_{DD} and V_{SS} (Typ. $V_{REF} = V_{DD} / 2$)	—

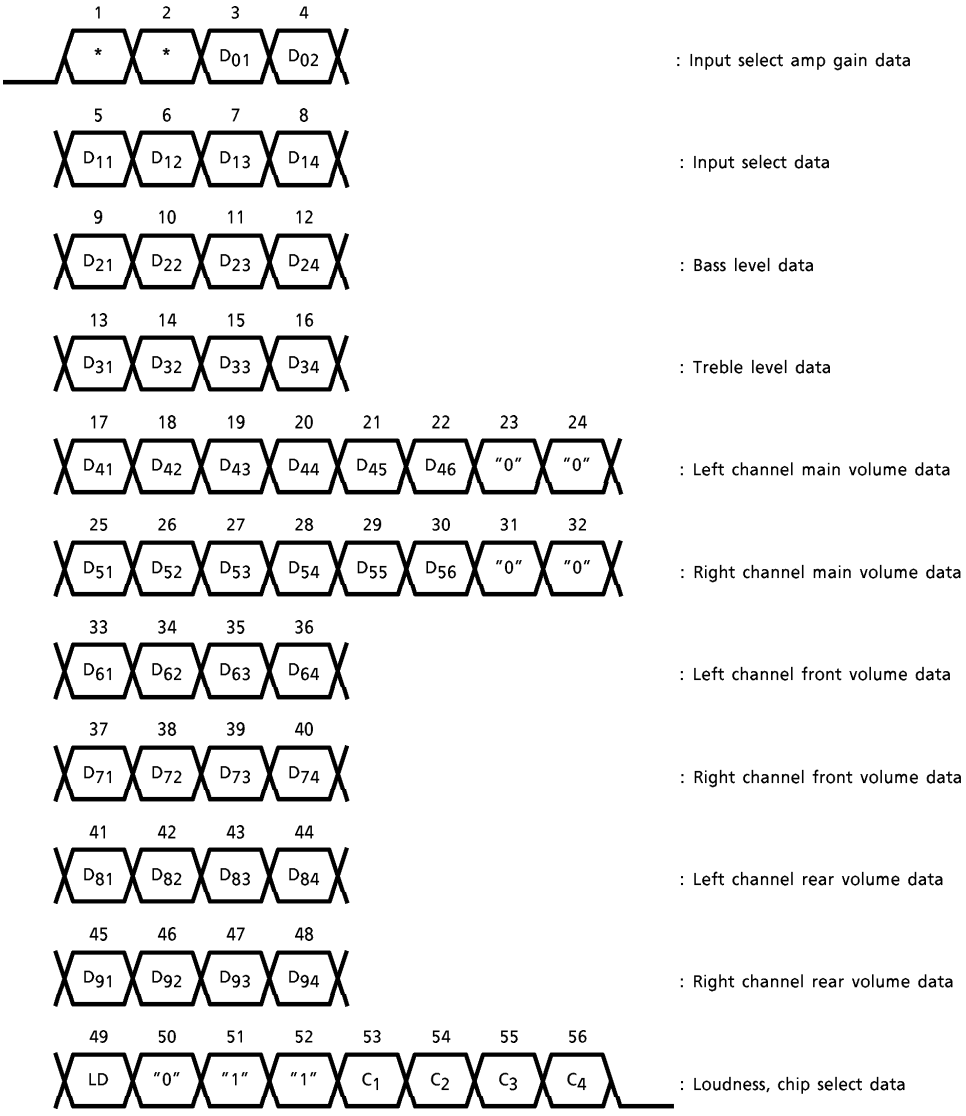
OPERATION

1. Volume data setting

Set volume using serial data input from the CK, DATA, and STB pins. Volume data contain 56 bits.



1) Volume control data assignment (* : Can be omitted)

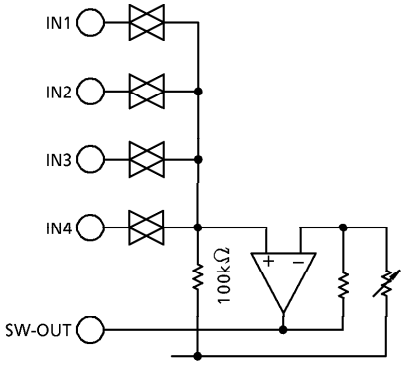


2) Chip select data (C_1~C_4)

Chip select code to enable serial data line to be shared with other ICs.
For TC9421F, set C_1 = "1", C_2 = C_3 = "0", C_4 = "1" (1001 : 9H).

2. Input select circuit

1) Equivalent circuit



2) Input select and gain settings

- Gain setting

D_{01}	D_{02}	GAIN
0	0	0dB
1	0	6dB
0	1	10dB
1	1	12dB

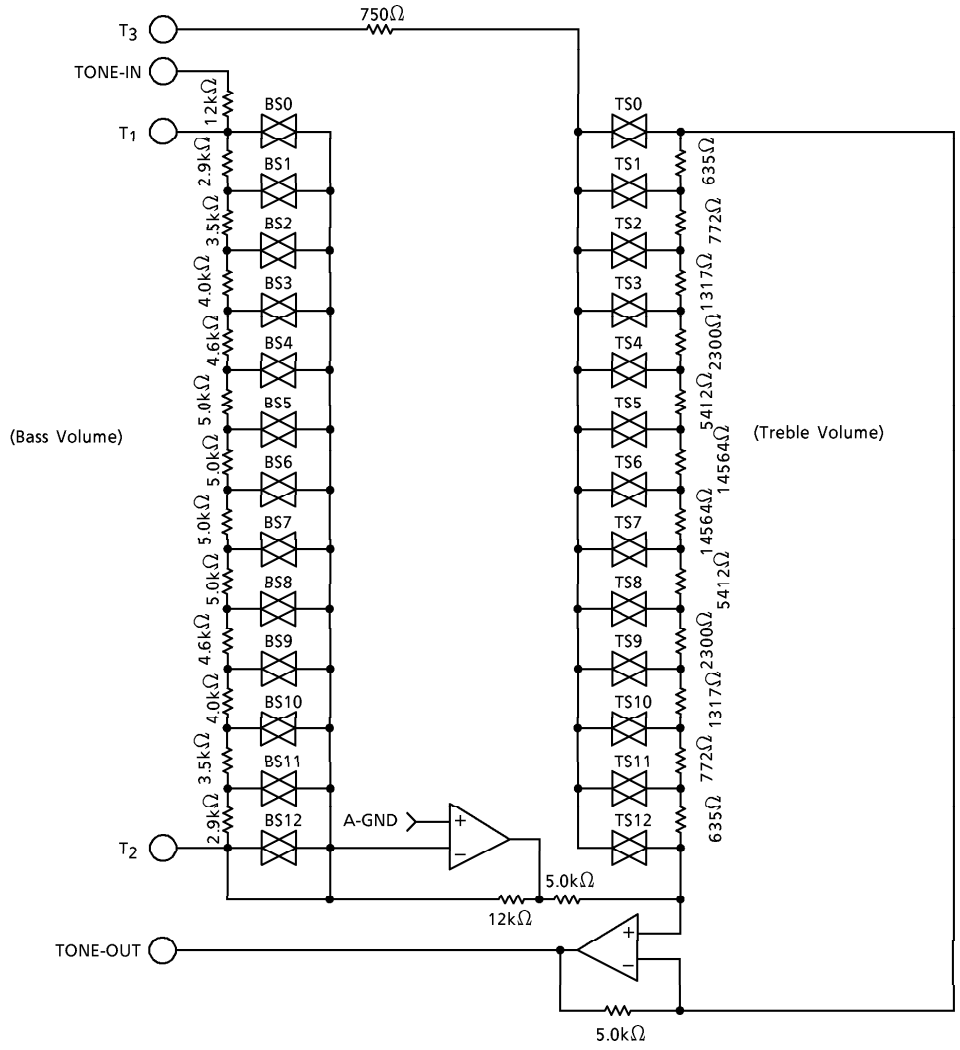
- Input select settings

D_{11}	D_{12}	D_{13}	D_{14}	SW_1	SW_2	SW_3	SW_4
0	0	0	0	OFF	OFF	OFF	OFF
1	—	—	—	ON	—	—	—
—	1	—	—	—	ON	—	—
—	—	1	—	—	—	ON	—
—	—	—	1	—	—	—	ON

(*) If turning on two or more among switches SW_1~SW_4 at the same time, connect 10kΩ or higher to the input pins (IN1~IN4).

3. Tone control circuit

1) Equivalent circuit



2) Bass and treble level settings

- Bass level settings

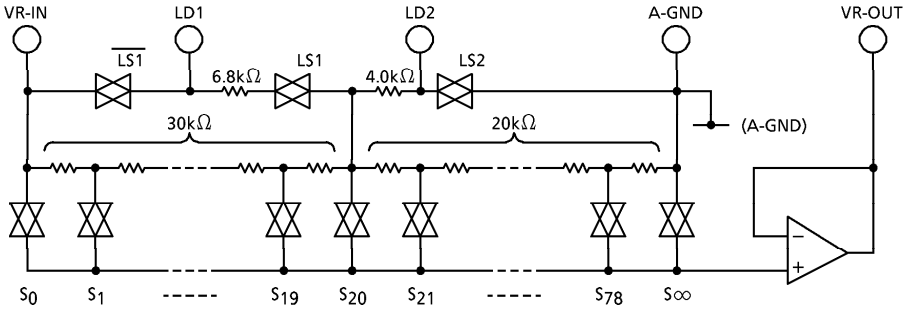
D_{21}	D_{22}	D_{23}	D_{24}	VOLUME VALUE
0	1	1	0	+ 12dB
1	0	1	0	+ 10dB
0	0	1	0	+ 8dB
1	1	0	0	+ 6dB
0	1	0	0	+ 4dB
1	0	0	0	+ 2dB
0	0	0	0	0dB
1	1	1	1	– 2dB
0	1	1	1	– 4dB
1	0	1	1	– 6dB
0	0	1	1	– 8dB
1	1	0	1	– 10dB
0	1	0	1	– 12dB

- Treble level settings

D_{31}	D_{32}	D_{33}	D_{34}	VOLUME VALUE
0	1	1	0	+ 12dB
1	0	1	0	+ 10dB
0	0	1	0	+ 8dB
1	1	0	0	+ 6dB
0	1	0	0	+ 4dB
1	0	0	0	+ 2dB
0	0	0	0	0dB
1	1	1	1	– 2dB
0	1	1	1	– 4dB
1	0	1	1	– 6dB
0	0	1	1	– 8dB
1	1	0	1	– 10dB
0	1	0	1	– 12dB

4. Main volume circuit

1) Equivalent circuit



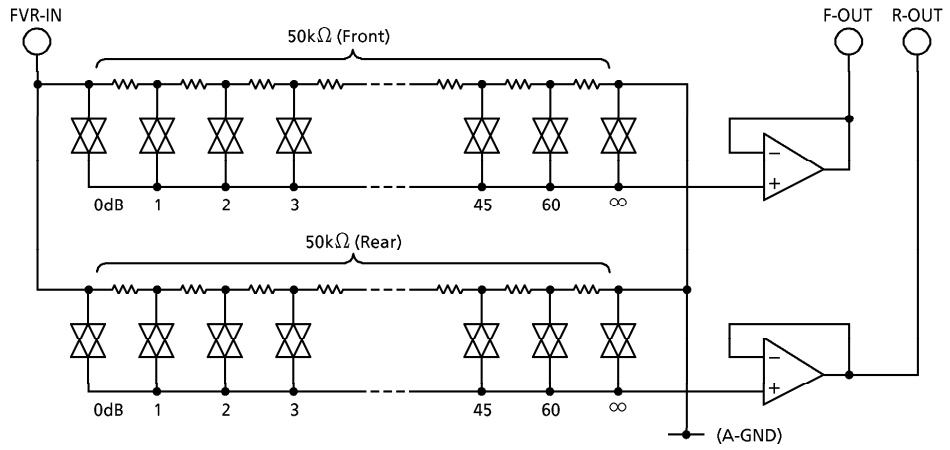
- The loudness pin is connected to a 20dB tap.
- When the loudness is ON : LS1 = ON, $\overline{LS1}$ = OFF, LS2 = OFF
  When the loudness is OFF : LS1 = OFF, $\overline{LS1}$ = ON, LS2 = ON

2) Main volume settings

VOLUME VALUE	D41	D42	D43	D44	D45	D46	VOLUME VALUE	D41	D42	D43	D44	D45	D46	VOLUME VALUE	D41	D42	D43	D44	D45	D46	VOLUME VALUE	D41	D42	D43	D44	D45	D46
	D51	D52	D53	D54	D55	D56		D51	D52	D53	D54	D55	D56		D51	D52	D53	D54	D55	D56		D51	D52	D53	D54	D55	D56
0dB	0	0	0	0	0	0	16dB	0	0	0	0	1	0	32dB	0	0	0	0	0	1	52dB	0	0	0	0	1	1
1dB	1	0	0	0	0	0	17dB	1	0	0	0	1	0	33dB	1	0	0	0	0	1	54dB	1	0	0	0	1	1
2dB	0	1	0	0	0	0	18dB	0	1	0	0	1	0	34dB	0	1	0	0	0	1	56dB	0	1	0	0	1	1
3dB	1	1	0	0	0	0	19dB	1	1	0	0	1	0	35dB	1	1	0	0	0	1	58dB	1	1	0	0	1	1
4dB	0	0	1	0	0	0	20dB	0	0	1	0	1	0	36dB	0	0	1	0	0	1	60dB	0	0	1	0	1	1
5dB	1	0	1	0	0	0	21dB	1	0	1	0	1	0	37dB	1	0	1	0	0	1	62dB	1	0	1	0	1	1
6dB	0	1	1	0	0	0	22dB	0	1	1	0	1	0	38dB	0	1	1	0	0	1	64dB	0	1	1	0	1	1
7dB	1	1	1	0	0	0	23dB	1	1	1	0	1	0	39dB	1	1	1	0	0	1	66dB	1	1	1	0	1	1
8dB	0	0	0	1	0	0	24dB	0	0	0	1	1	0	40dB	0	0	0	1	0	1	68dB	0	0	0	1	1	1
9dB	1	0	0	1	0	0	25dB	1	0	0	1	1	0	41dB	1	0	0	1	0	1	70dB	1	0	0	1	1	1
10dB	0	1	0	1	0	0	26dB	0	1	0	1	1	0	42dB	0	1	0	1	0	1	72dB	0	1	0	1	1	1
11dB	1	1	0	1	0	0	27dB	1	1	0	1	1	0	43dB	1	1	0	1	0	1	74dB	1	1	0	1	1	1
12dB	0	0	1	1	0	0	28dB	0	0	1	1	1	0	44dB	0	0	1	1	0	1	76dB	0	0	1	1	1	1
13dB	1	0	1	1	0	0	29dB	1	0	1	1	1	0	46dB	1	0	1	1	0	1	78dB	1	0	1	1	1	1
14dB	0	1	1	1	0	0	30dB	0	1	1	1	1	0	48dB	0	1	1	1	0	1	∞dB	0	1	1	1	1	1
15dB	1	1	1	1	0	0	31dB	1	1	1	1	1	0	50dB	1	1	1	1	0	1							

5. Fader volume circuit

1) Equivalent circuit



2) Fader volume setting

- Front volume setting

VOLUME VALUE	D_{61}	D_{62}	D_{63}	D_{64}
	D_{71}	D_{72}	D_{73}	D_{74}
0dB	0	0	0	0
1dB	1	0	0	0
2dB	0	1	0	0
3dB	1	1	0	0
4dB	0	0	1	0
6dB	1	0	1	0
8dB	0	1	1	0
10dB	1	1	1	0
12dB	0	0	0	1
14dB	1	0	0	1
16dB	0	1	0	1
20dB	1	1	0	1
30dB	0	0	1	1
45dB	1	0	1	1
60dB	0	1	1	1
∞dB	1	1	1	1

- Rear volume setting

VOLUME VALUE	D_{81}	D_{82}	D_{83}	D_{84}
	D_{91}	D_{92}	D_{93}	D_{94}
0dB	0	0	0	0
1dB	1	0	0	0
2dB	0	1	0	0
3dB	1	1	0	0
4dB	0	0	1	0
6dB	1	0	1	0
8dB	0	1	1	0
10dB	1	1	1	0
12dB	0	0	0	1
14dB	1	0	0	1
16dB	0	1	0	1
20dB	1	1	0	1
30dB	0	0	1	1
45dB	1	0	1	1
60dB	0	1	1	1
∞dB	1	1	1	1

MAXIMUM RATINGS (Ta = 25°C)

CHRACTERISTIC	SYMBOL	RATING	UNIT
Supply Voltage	V_{DD} / V_{CC}	− 0.3~15	V
Input Voltage	V_{IN}	− 0.3~V_{DD} / V_{CC} + 0.3	V
Power Dissipation	P_D	300	mW
Operating Temperature	T_{opr}	− 40~85	°C
Storage Temperature	T_{stg}	− 65~150	°C

ELECTRICAL SPECIFICATIONS (Unless otherwise specified, Ta = 25°C, V_{DD} = V_{CC} = 9.0V)

CHARACTERISTIC		SYMBOL	TEST CIR-CUIT	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
Operating Supply Voltage		V_{DD} / V_{CC}	—	Ta = − 40~85°C		6.0	9.0	12.0	V
Operating Supply Current		I_{CC} + I_{DD}	1	No input, no load		—	15.0	30.0	mA
Input Voltage	"H" Level	V_{IH}	—	CK, DATA, STB pins V_{DD} = 6.0~12V		4.0	~	V_{DD}	V
	"L" Level	V_{IL}				0	~	1.0	
Input Current	"H" Level	I_{IH}	—		V_{IH} = V_{DD}	− 1.0	~	1.0	μA
	"L" Level	I_{IL}			V_{IL} = 0V	− 1.0	~	1.0	
Volume Control Resistance		R_{VR}	—	Main volume, LD = OFF		35	50	65	kΩ
		R_{TO}		Tone volume		35	50	65	
		R_{FD}		Fader volume		35	50	65	
Input Resistance		R_{IN}	—	IN1~IN4 input resistance		21	30	39	
Setup Time		t_{SET}	2	CK, DATA, STB signals		1.0	—	—	μs
Data Hold Time		t_{HOLD}				1.0	—	—	
Input Pulse Width		t_W				1.0	—	—	
Operating Frequency		f_{OP}		CK signals		—	—	500	kHz

- Input selector block

Maximum Input Level		V_{INMAX}	—	f_{IN} = 1kHz, G_V = 0dB THD = 1%, R_L = 12kΩ		—	2.0	—	V_{rms}
Input Gain		G_{V1}		f_{IN} = 1kHz R_g = 600Ω	G_V = 0dB	− 1.5	0	1.5	dB
		G_{V2}			G_V = 6dB	4.5	6	7.5	
		G_{V3}			G_V = 10dB	8.5	10	11.5	
		G_{V4}			G_V = 12dB	10.5	12	13.5	

- Main volume block

Step Resolution	ΔSTEP	—	0dB~44dB	0.5	1	1.5	dB
			44dB~78dB	1	2	3	
Output Load Resistance	R_L		VR-OUT pins	12	25	—	kΩ

- Tone control block

CHARACTERISTIC	SYMBOL	TEST CIR-CUIT	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
Control Range	G_{VT}	—	Maximum boost / cut	±10	±12	±15	dB
Step Resolution	ΔSTEP		—	1	2	3	
Output Load Resistance	R_L		TONE-OUT pin	12	50	—	kΩ

- Fader volume block

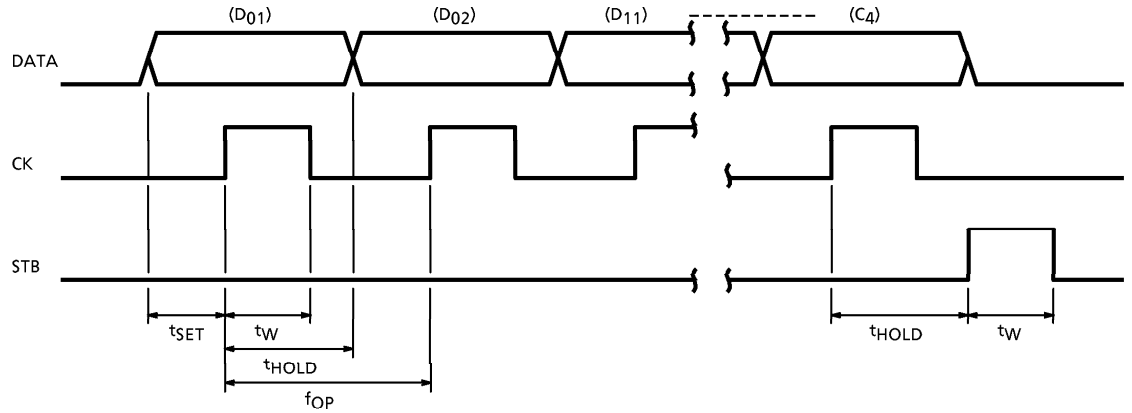
Step Resolution	ΔSTEP	—	0dB~4dB	0.5	1.0	1.5	dB
			4dB~16dB	1	2	3	
Output Load Resistance	R_L		F-OUT / R-OUT pins	12	33	—	kΩ

- Overall characteristics

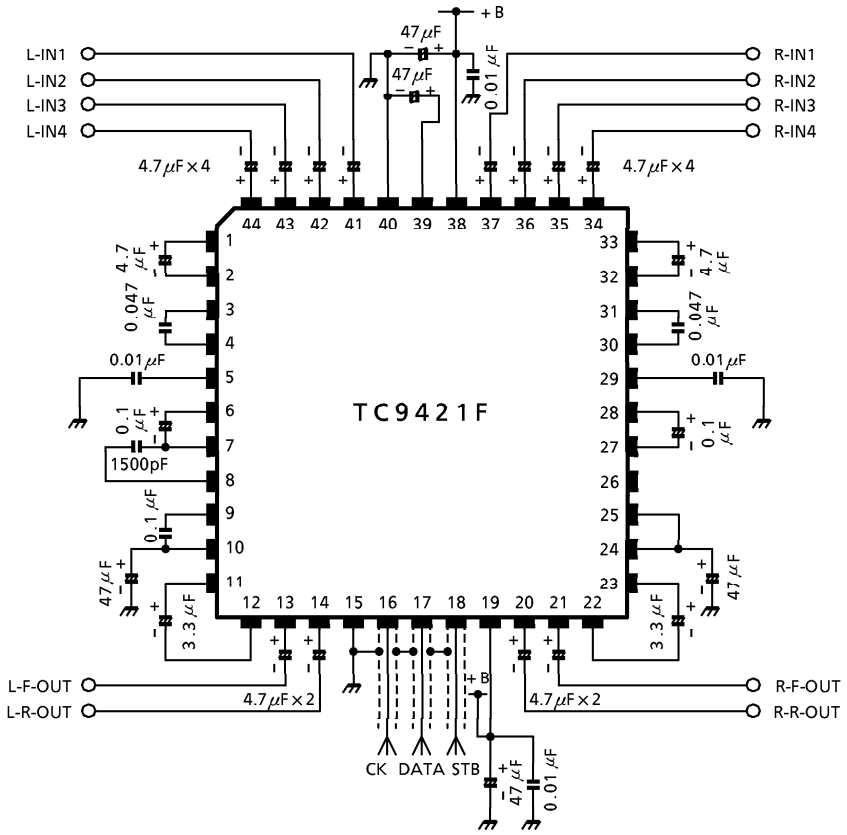
Overall Harmonic Distortion Ratio	THD (1)	1	V_{IN} = 300mVrms, All set to flat, R_g = 600Ω, R_L = 33kΩ	f_{IN} = 1kHz	—	0.005	0.01	%
	THD (2)			f_{IN} = 20kHz	—	0.008	0.02	
Crosstalk	TC		V_{IN} = 1Vrms, R_g = 600Ω, f_{IN} = 1kHz, All set to flat		60	80	—	dB
Maximum Attenuation	AT_{MAX}		V_{IN} = 1Vrms, f_{IN} = 1kHz, R_L = 33kΩ、Main volume ∞		60	80	—	dB
Output Noise Voltage	V_N (1)		R_g = 600Ω (IHF-A), All set to flat		—	5.0	12.0	μVrms
	V_N (2)		R_g = 600Ω (IHF-A), Bass / treble set to maximum boost, Input amp set to +12dB		—	5.0	120	

Test circuit 1 : Application circuit example used

Test circuit 2 : Serial data timing



APPLICATION CIRCUIT



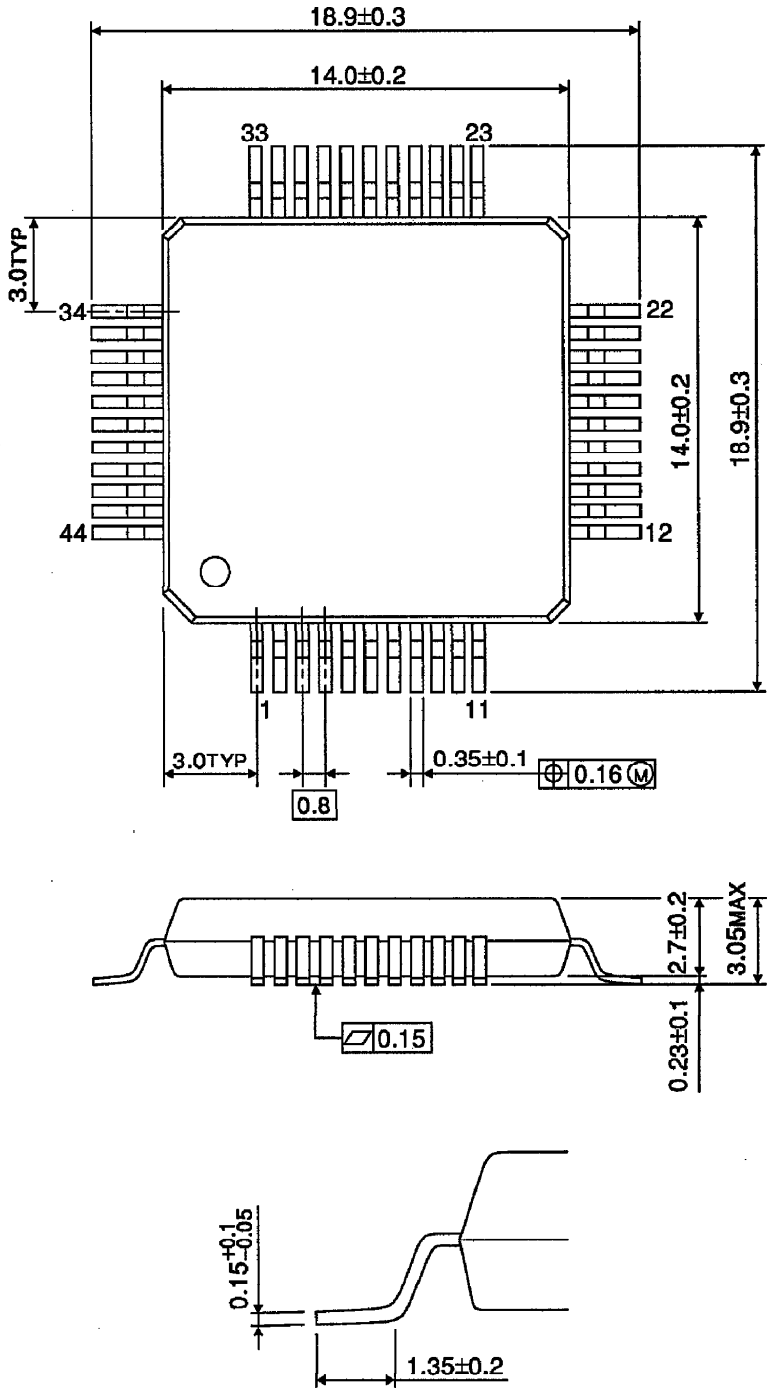
- The circuit example shows the left channel with loudness control and the right channel with no loudness control.

(Note) As the CK, DATA, and STB pins receive microcontroller communication digital signals, take measures to prevent digital signals leaking to analog circuits, thus causing noise. For example, use a ground pattern to guard the pins or use a shielded line.

OUTLINE DRAWING

QFP44-P-1414-0.80D

Unit : mm



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