

TC9421F

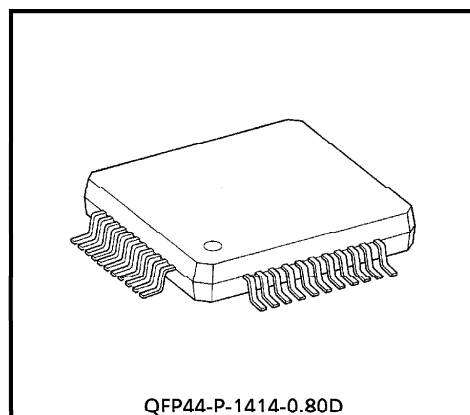
SYSTEM ELECTRONIC VOLUME

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.

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 : ± 12 dB 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.

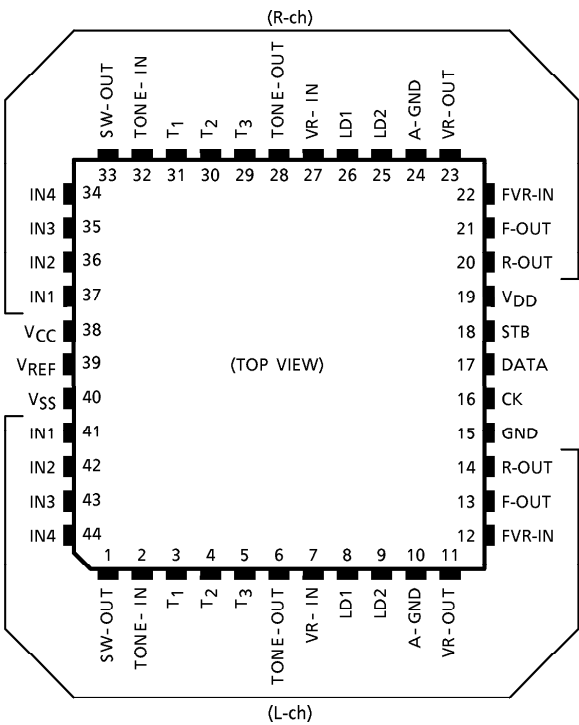


Weight : 1.1g (Typ.)

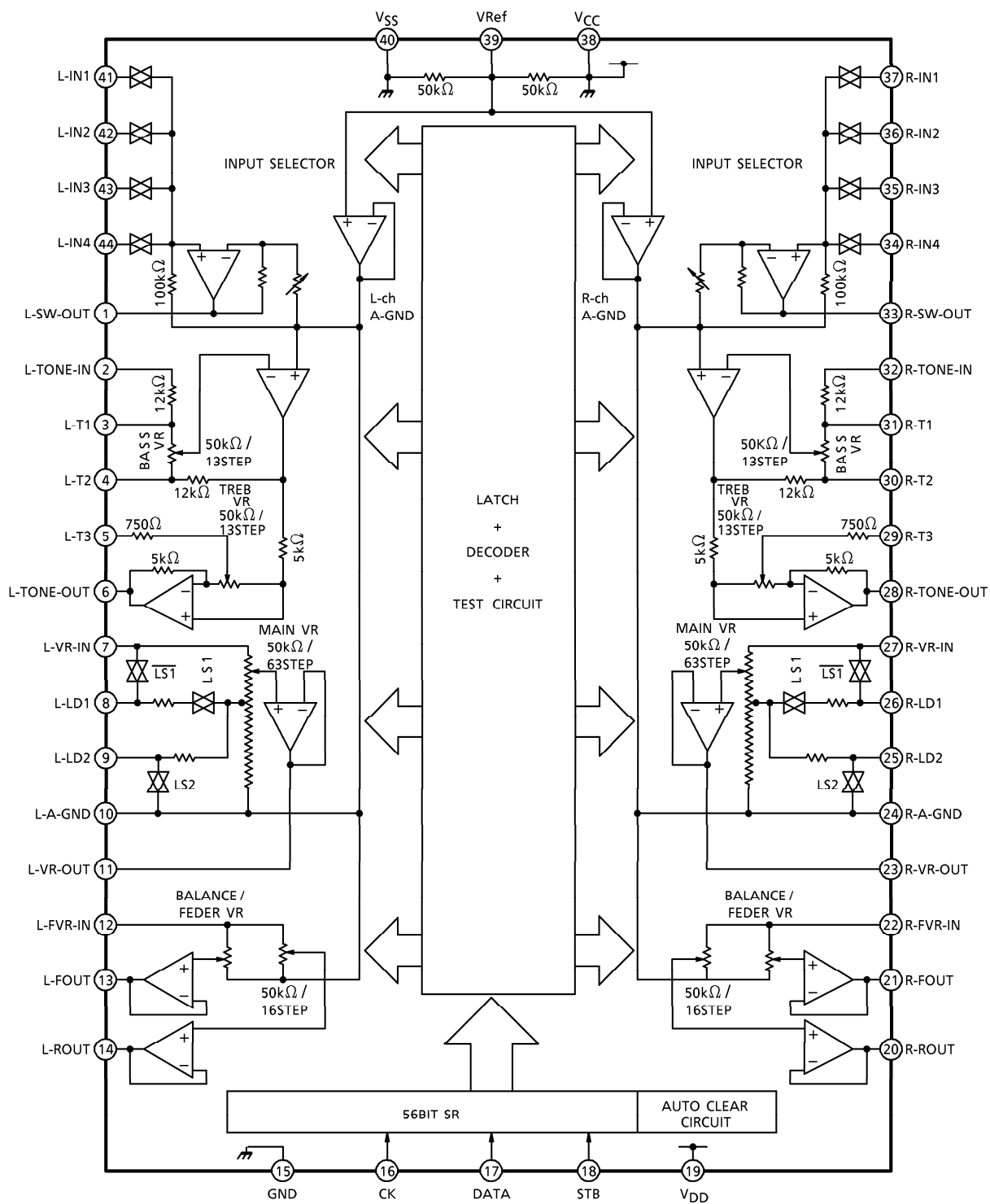
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PIN CONNECTION



BLOCK DIAGRAM



DESCRIPTION OF PINS

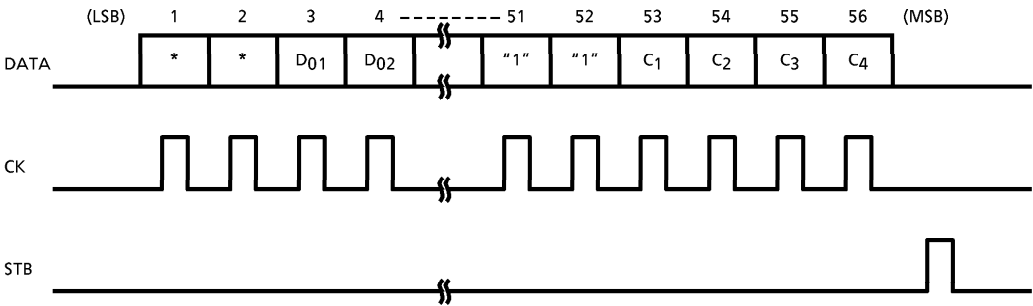
PIN No.	SYMBOL	PIN NAME	FUNCTION AND OPERATION	REMARKS		
41	L-IN1	Audio signal input pins	- Four input selector circuits - Input switches can be controlled independently - Op amp circuit gain can be set to 0dB, 6dB, 10dB, or 12dB	—		
42	L-IN2					
43	L-IN3					
44	L-IN4					
37	R-IN1					
36	R-IN2					
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 T₁ and T₂ - Insert treble control capacitor between T₁ (T₂) and T₃ - 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	VCC	Analog power supply pin	● Use with $V_{CC} = V_{DD}$	—
19	VDD	Digital power supply pin		
40	VSS	Analog ground pin	● Ground pins	—
15	GND	Digital ground pin		
39	VREF	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. $V_{REF} = V_{DD} / 2$)	—

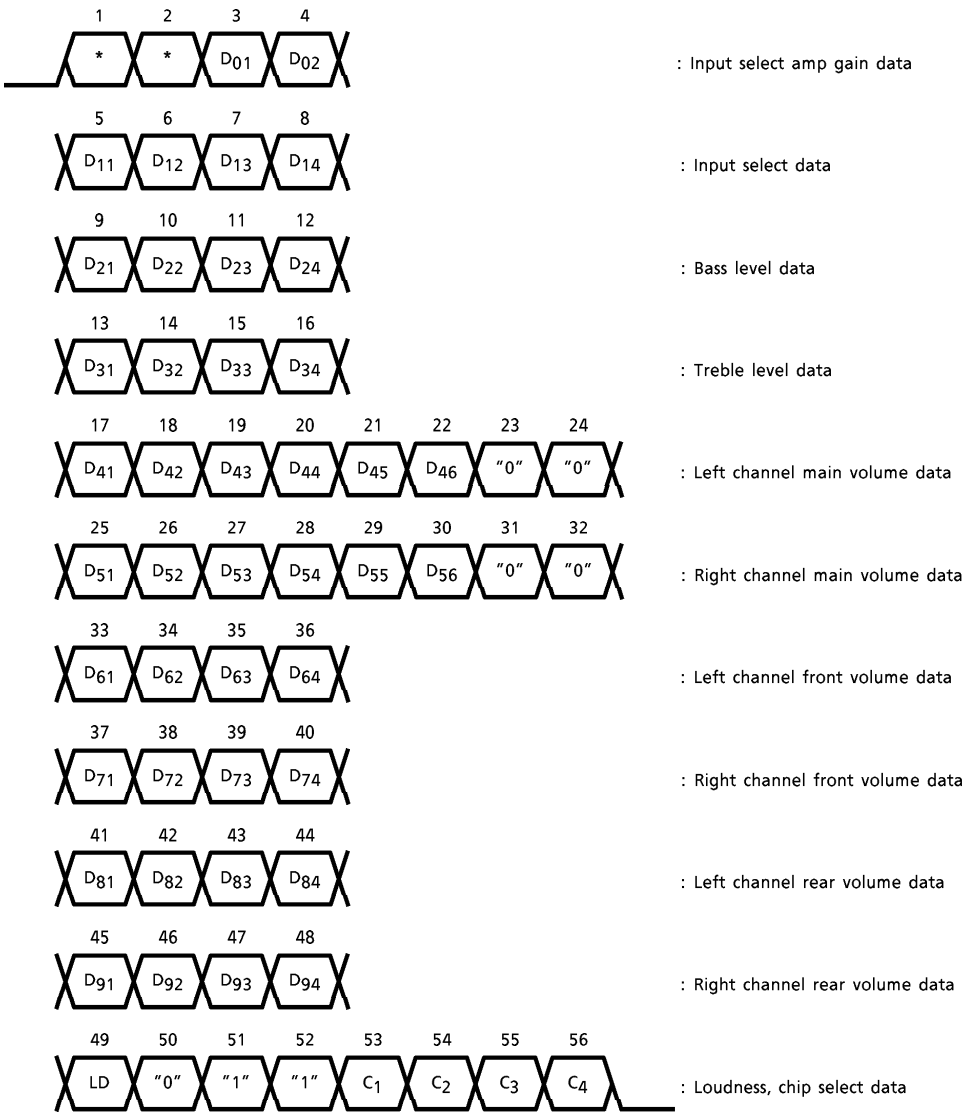
OPERATION

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)

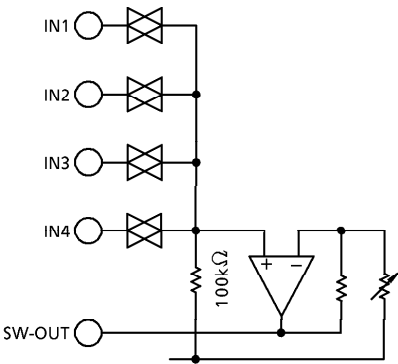


2) Chip select data (C₁~C₄)

Chip select code to enable serial data line to be shared with other ICs.
For TC9421F, set C₁ = "1", C₂ = C₃ = "0", C₄ = "1" (1001 : 9H).

2. Input select circuit

1) Equivalent circuit



2) Input select and gain settings

- Gain setting

D01	D02	GAIN
0	0	0dB
1	0	6dB
0	1	10dB
1	1	12dB

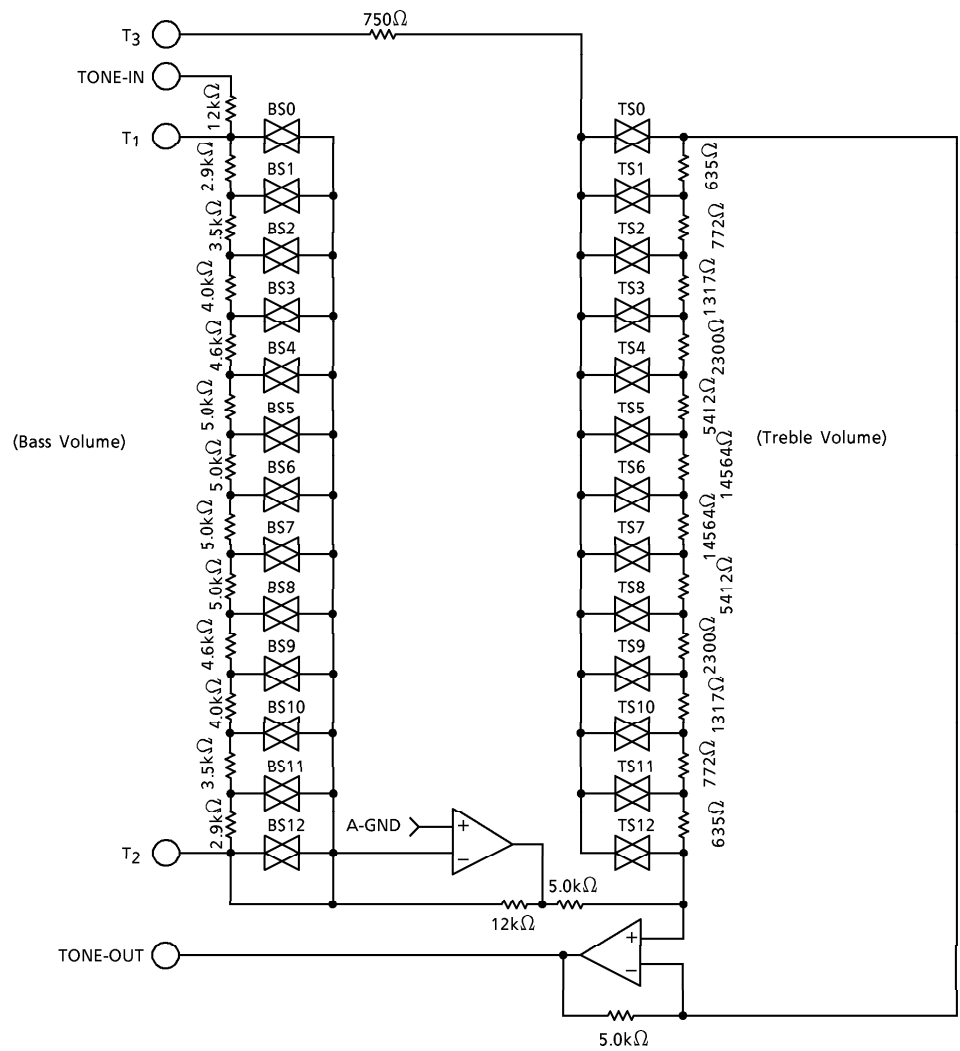
- Input select settings

D11	D12	D13	D14	SW1	SW2	SW3	SW4
0	0	0	0	OFF	OFF	OFF	OFF
1	—	—	—	ON	—	—	—
—	1	—	—	—	ON	—	—
—	—	1	—	—	—	ON	—
—	—	—	1	—	—	—	ON

(*) If turning on two or more among switches SW1~SW4 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

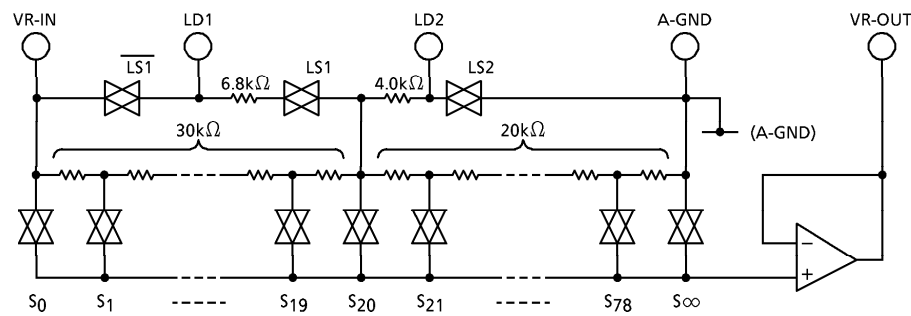
D ₂₁	D ₂₂	D ₂₃	D ₂₄	VOLUME VALUE
0	1	1	0	+ 12dB
1	0	1	0	+ 10dB
0	0	1	0	+ 8dB
1	1	0	0	+ 6dB
0	1	0	0	+ 4dB
1	0	0	0	+ 2dB
0	0	0	0	0dB
1	1	1	1	- 2dB
0	1	1	1	- 4dB
1	0	1	1	- 6dB
0	0	1	1	- 8dB
1	1	0	1	- 10dB
0	1	0	1	- 12dB

• 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



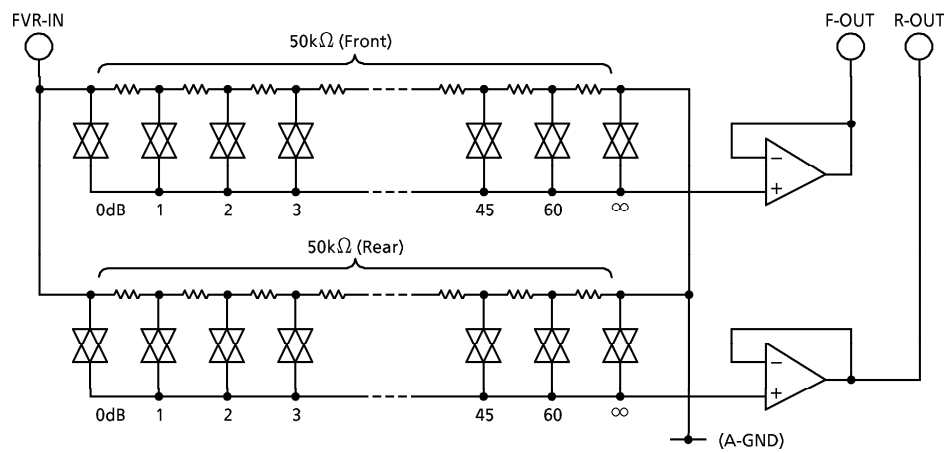
- The loudness pin is connected to a 20dB tap.
- When the loudness is ON : LS1 = ON, $\overline{\text{LS1}}$ = OFF, LS2 = OFF
When the loudness is OFF : LS1 = OFF, $\overline{\text{LS1}}$ = ON, LS2 = ON

2) Main volume settings

VOLUME VALUE	D 41	D 42	D 43	D 44	D 45	D 46	VOLUME VALUE	D 41	D 42	D 43	D 44	D 45	D 46	VOLUME VALUE	D 41	D 42	D 43	D 44	D 45	D 46	VOLUME VALUE	D 41	D 42	D 43	D 44	D 45	D 46
	D 51	D 52	D 53	D 54	D 55	D 56		D 51	D 52	D 53	D 54	D 55	D 56		D 51	D 52	D 53	D 54	D 55	D 56		D 51	D 52	D 53	D 54	D 55	D 56
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	D61	D62	D63	D64
	D71	D72	D73	D74
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	D81	D82	D83	D84
	D91	D92	D93	D94
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 ($T_a = 25^\circ\text{C}$)

CHARACTERISTIC	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	$^\circ\text{C}$
Storage Temperature	T_{stg}	-65~150	$^\circ\text{C}$

ELECTRICAL SPECIFICATIONS (Unless otherwise specified, $T_a = 25^\circ\text{C}$, $V_{DD} = V_{CC} = 9.0\text{V}$)

CHARACTERISTIC	SYMBOL	TEST CIR- CUIT	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Supply Voltage	V_{DD}/V_{CC}	—	$T_a = -40\sim 85^\circ\text{C}$	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 $V_{DD} = 6.0\sim 12\text{V}$	4.0	~	V_{DD}	V
	"L" Level	V_{IL}		0	~	1.0	
Input Current	"H" Level	I_{IH}		-1.0	~	1.0	μA
	"L" Level	I_{IL}		-1.0	~	1.0	
Volume Control Resistance	R_{VR}	—	Main volume, LD = OFF	35	50	65	$\text{k}\Omega$
	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}	—	$f_{IN} = 1\text{kHz}$, $G_V = 0\text{dB}$ $\text{THD} = 1\%$, $R_L = 12\text{k}\Omega$		—	2.0	—	V_{rms}
Input Gain	G_{V1}		$f_{IN} = 1\text{kHz}$ $R_g = 600\Omega$	$G_V = 0\text{dB}$	-1.5	0	1.5	dB
	G_{V2}			$G_V = 6\text{dB}$	4.5	6	7.5	
	G_{V3}			$G_V = 10\text{dB}$	8.5	10	11.5	
	G_{V4}			$G_V = 12\text{dB}$	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	—	$\text{k}\Omega$

● 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	$\Delta STEP$		—	1	2	3	
Output Load Resistance	R_L		TONE-OUT pin	12	50	—	k Ω

● Fader volume block

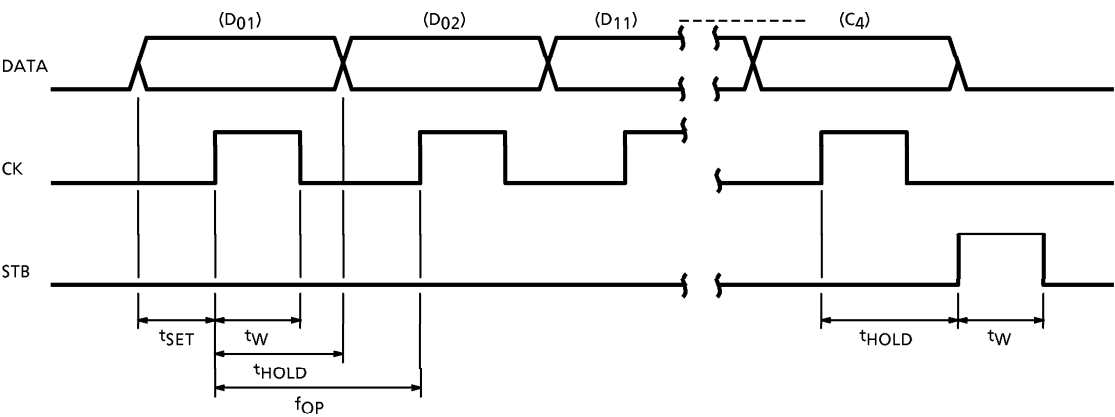
Step Resolution	$\Delta STEP$	—	0dB~4dB	0.5	1.0	1.5	dB
			4dB~16dB	1	2	3	
Output Load Resistance	R_L		F-OUT / R-OUT pins	12	33	—	k Ω

● Overall characteristics

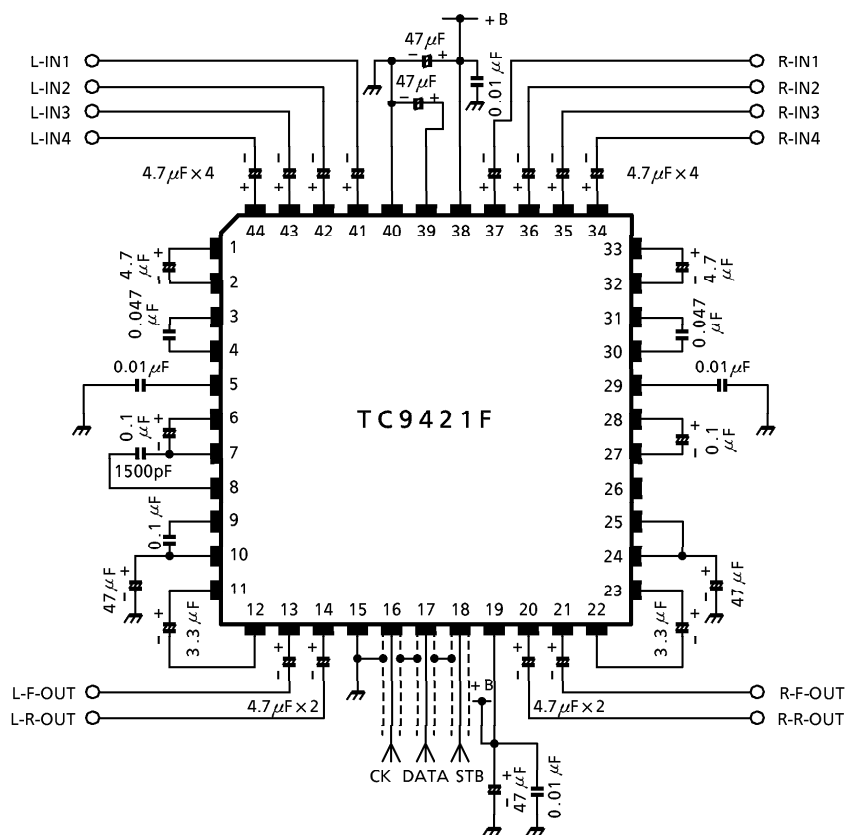
Overall Harmonic Distortion Ratio	THD (1)	1	$V_{IN} = 300mV_{rms}$ All set to flat $R_g = 600\Omega$ $R_L = 33k\Omega$	$f_{IN} = 1kHz$	—	0.005	0.01	%
	THD (2)			$f_{IN} = 20kHz$	—	0.008	0.02	
Crosstalk	TC		$V_{IN} = 1V_{rms}$, $R_g = 600\Omega$ $f_{IN} = 1kHz$, All set to flat		60	80	—	dB
Maximum Attenuation	AT_{MAX}		$V_{IN} = 1V_{rms}$, $f_{IN} = 1kHz$ $R_L = 33k\Omega$ 、 Main volume ∞		60	80	—	dB
Output Noise Voltage	$V_N (1)$		$R_g = 600\Omega$ (IHF-A) All set to flat		—	5.0	12.0	μV_{rms}
	$V_N (2)$		$R_g = 600\Omega$ (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

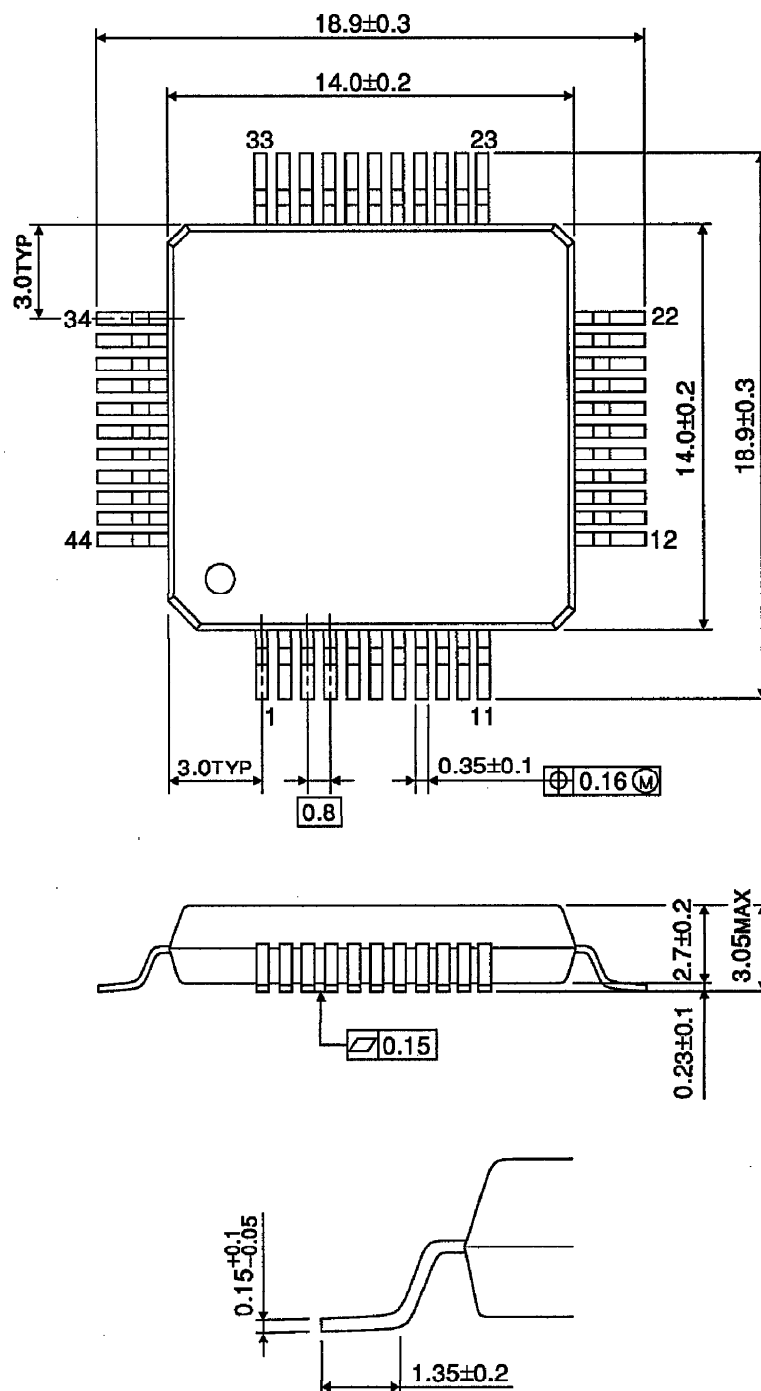


- The circuit example shows the left channel with loudness control and the right channel with no loudness control.

(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.

QFP44-P-1414-0.80D

Unit : mm



Weight : 1.1g (Typ.)