

TC9421F

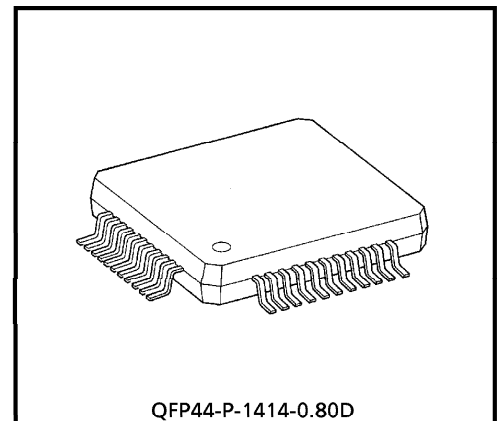
SYSTEM ELECTRONIC VOLUME

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.

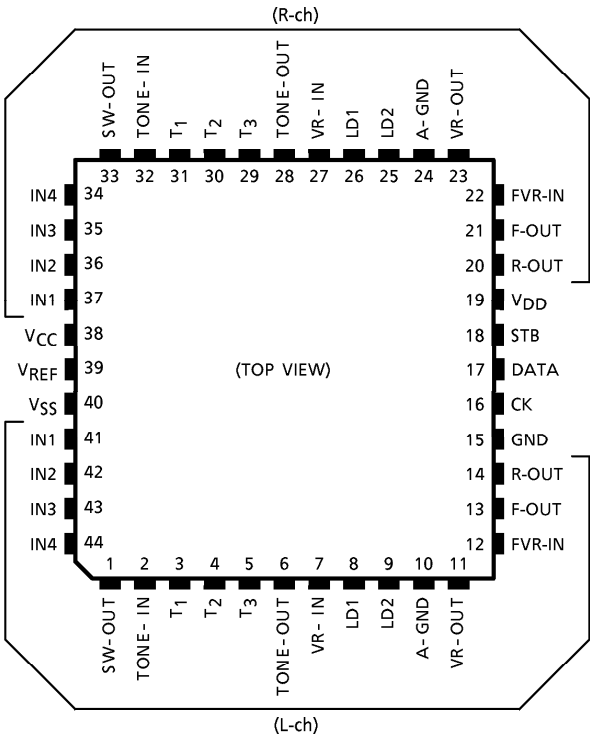
FEATURES

- 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.)

PIN CONNECTION



The diagram illustrates the internal architecture of the L5646C IC, a 56-bit shift register with a 16-step volume control. The central component is the **56BIT SR** (Shift Register) and **AUTO CLEAR CIRCUIT**, which are controlled by pins 15 (GND), 16 (CK), 17 (DATA), 18 (STB), and 19 (V_{DD}). The IC features two main signal paths: **L-ch A-GND** (Left Channel) and **R-ch A-GND** (Right Channel).

Input Stages: The **INPUT SELECTOR** blocks at the top of each channel manage the input signals. The left channel inputs include L-IN1 through L-IN4 (pins 41-44), L-TONE-IN (pin 2), L-T1 (pin 3), L-T2 (pin 4), L-T3 (pin 5), L-TONE-OUT (pin 6), L-VR-IN (pin 7), L-LD1 (pin 8), L-LD2 (pin 9), L-A-GND (pin 10), L-VR-OUT (pin 11), L-FVR-IN (pin 12), L-FOUT (pin 13), and L-ROUT (pin 14). The right channel inputs include R-IN1 through R-IN4 (pins 37-40), R-TONE-IN (pin 32), R-T1 (pin 31), R-T2 (pin 30), R-T3 (pin 29), R-TONE-OUT (pin 28), R-VR-IN (pin 27), R-LD1 (pin 26), R-LD2 (pin 25), R-A-GND (pin 24), R-VR-OUT (pin 23), R-FVR-IN (pin 22), R-FOUT (pin 21), and R-ROUT (pin 20).

Internal Components: The circuit includes several operational amplifiers (op-amps) and comparators. Key components include:

- 50kΩ / 13STEP** and **50kΩ / 16STEP** potentiometers for volume and balance control.
- 12kΩ**, **750Ω**, and **5kΩ** resistors for signal conditioning.
- 100kΩ** resistors for input biasing.
- LS1** and **LS2** diodes for signal routing.
- BASS VR** and **TREB VR** (Tone Control) potentiometers.
- MAIN VR** (Main Volume) potentiometer.
- 56kΩ** and **50kΩ** resistors for the shift register and auto-clear circuit.

Power and Grounding: The IC is powered by V_{SS} (pin 40), V_{Ref} (pin 39), and V_{CC} (pin 38). Ground connections are provided at pins 15 and 10.

DESCRIPTION OF PINS

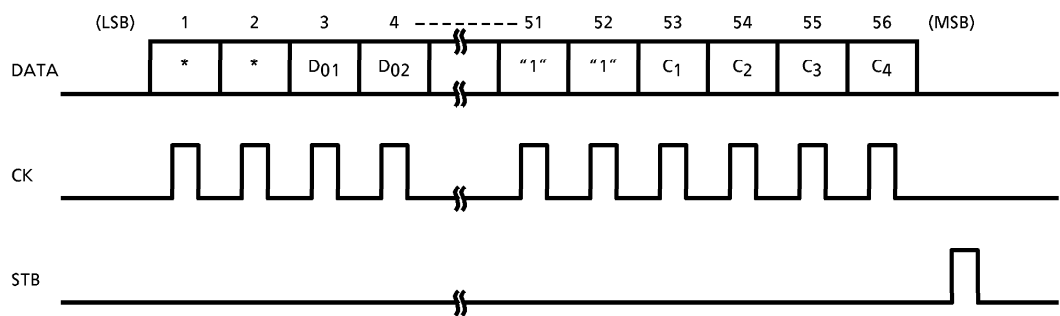
PIN No.	SYMBOL	PIN NAME	FUNCTION AND OPERATION	REMARKS
41	L-IN1	Audio signal input pins	● Four input selector circuits ● Input switches can be controlled independently ● Op amp circuit gain can be set to 0dB, 6dB, 10dB, or 12dB	—
42	L-IN2			
43	L-IN3			
44	L-IN4			
37	R-IN1			
36	R-IN2			
35	R-IN3			
34	R-IN4			
1	L-SW-OUT	Input selector output pins	● 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.)	—
33	R-SW-OUT			
2	L-TONE-IN	Tone circuit input pins		
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)	—

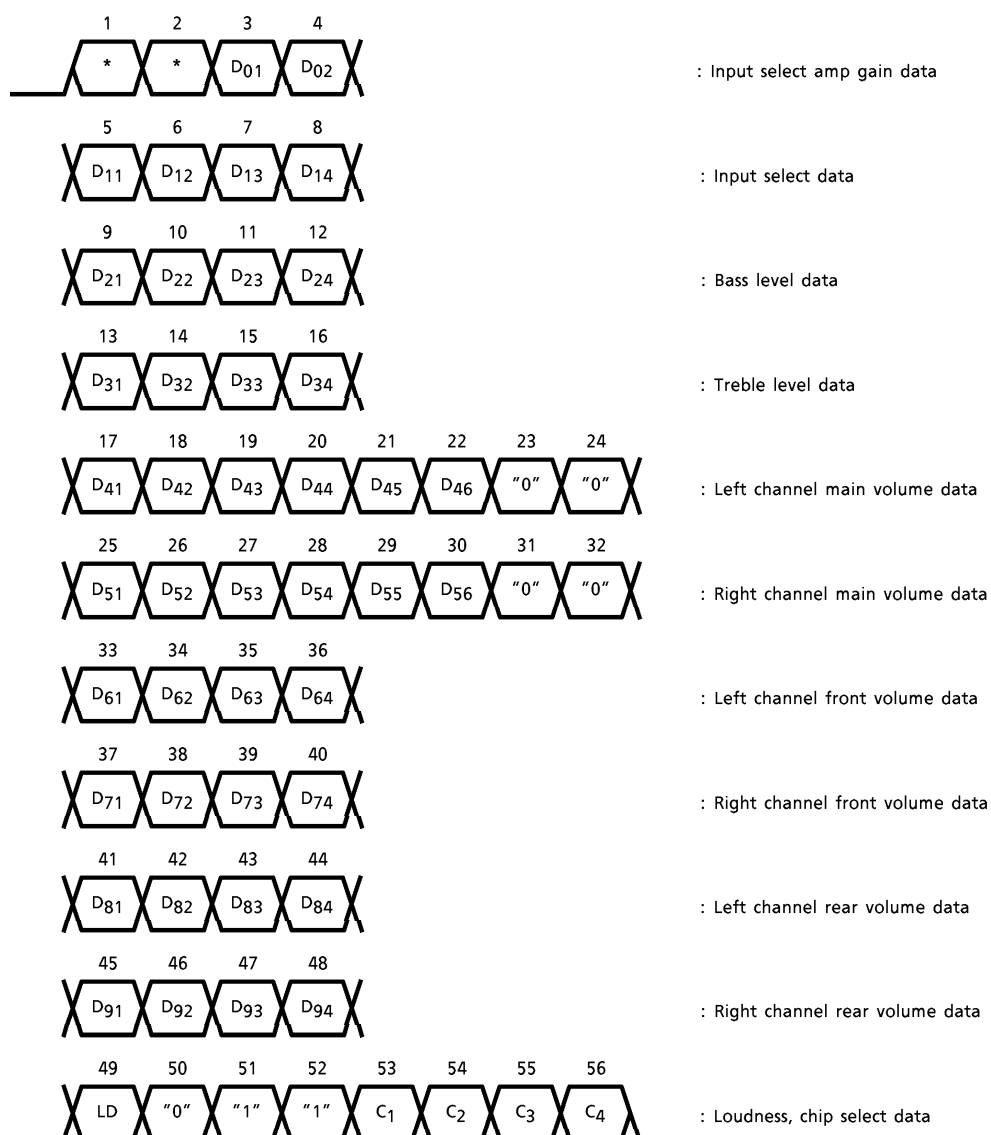
OPERATION

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)



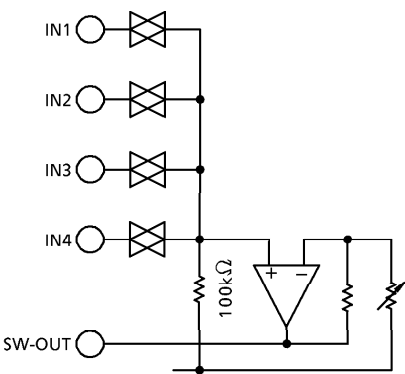
2) Chip select data (C₁~C₄)

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

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

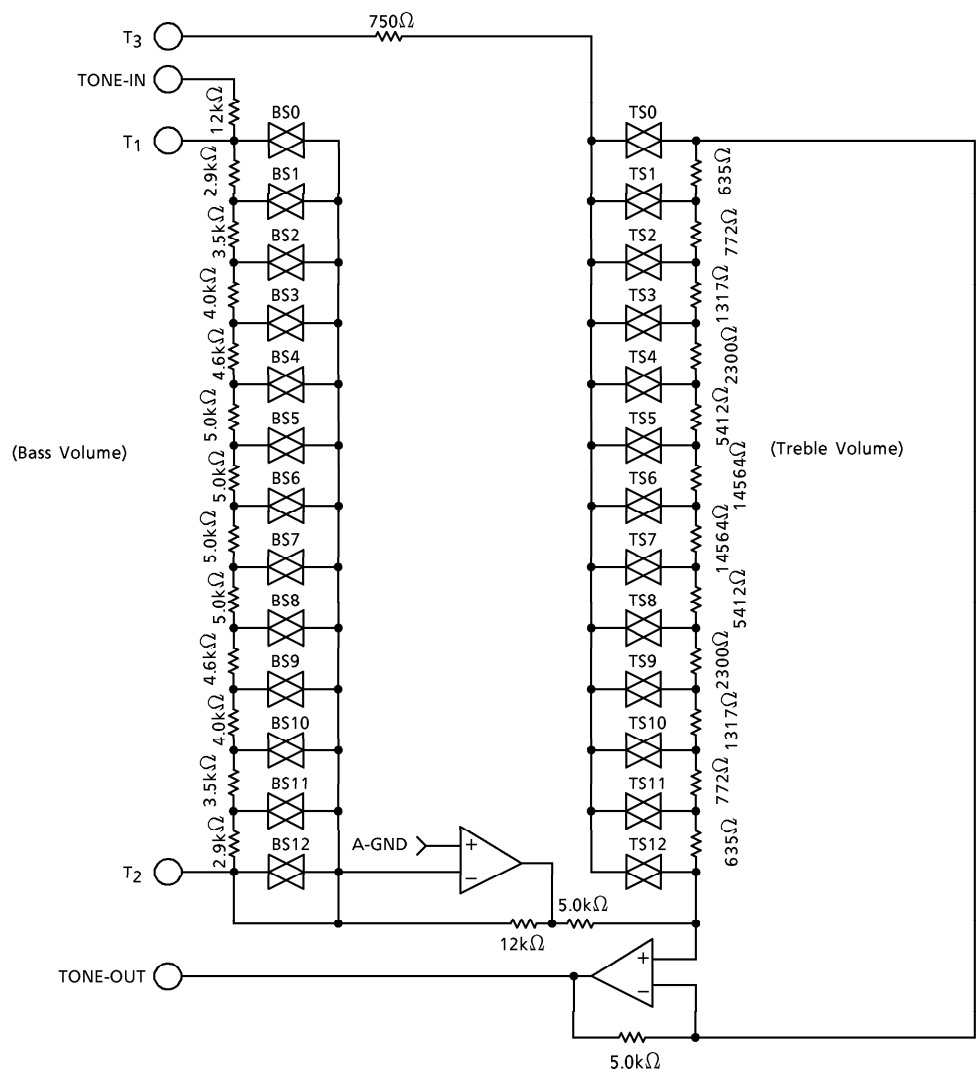
- Input select settings

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

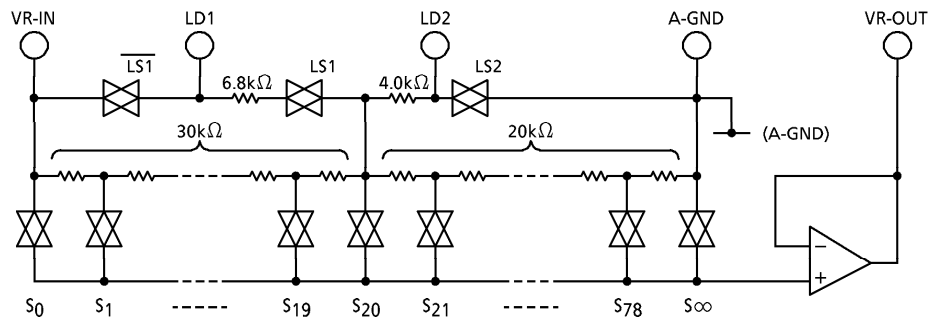
D ₂₁	D ₂₂	D ₂₃	D ₂₄	VOLUME VALUE
0	1	1	0	+ 12dB
1	0	1	0	+ 10dB
0	0	1	0	+ 8dB
1	1	0	0	+ 6dB
0	1	0	0	+ 4dB
1	0	0	0	+ 2dB
0	0	0	0	0dB
1	1	1	1	- 2dB
0	1	1	1	- 4dB
1	0	1	1	- 6dB
0	0	1	1	- 8dB
1	1	0	1	- 10dB
0	1	0	1	- 12dB

● 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



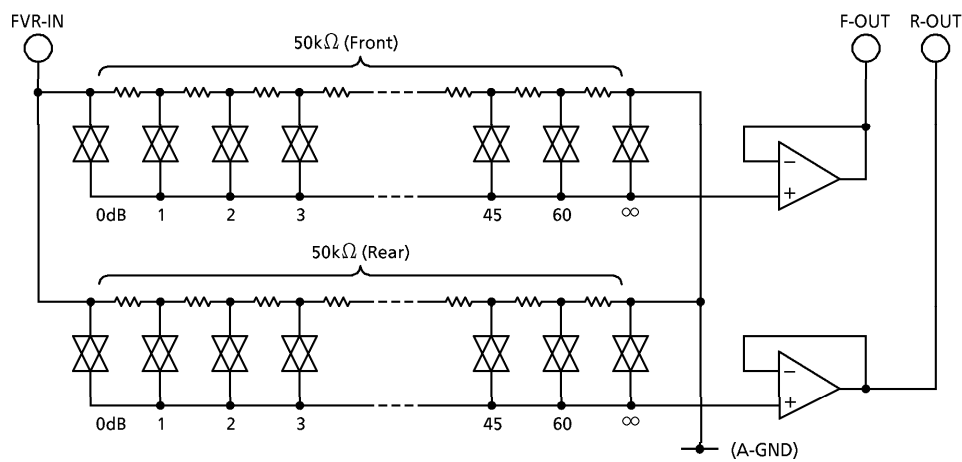
- The loudness pin is connected to a 20dB tap.
- When the loudness is ON : LS1 = ON, $\overline{LS1}$ = OFF, LS2 = OFF
When the loudness is OFF : LS1 = OFF, $\overline{LS1}$ = ON, LS2 = ON

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 (Ta = 25°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	°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	μA
	"L" Level	I _{IL}		V _{IL} = 0V	~	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	$\Delta STEP$		—	1	2	3	
Output Load Resistance	R_L		TONE-OUT pin	12	50	—	$k\Omega$

● Fader volume block

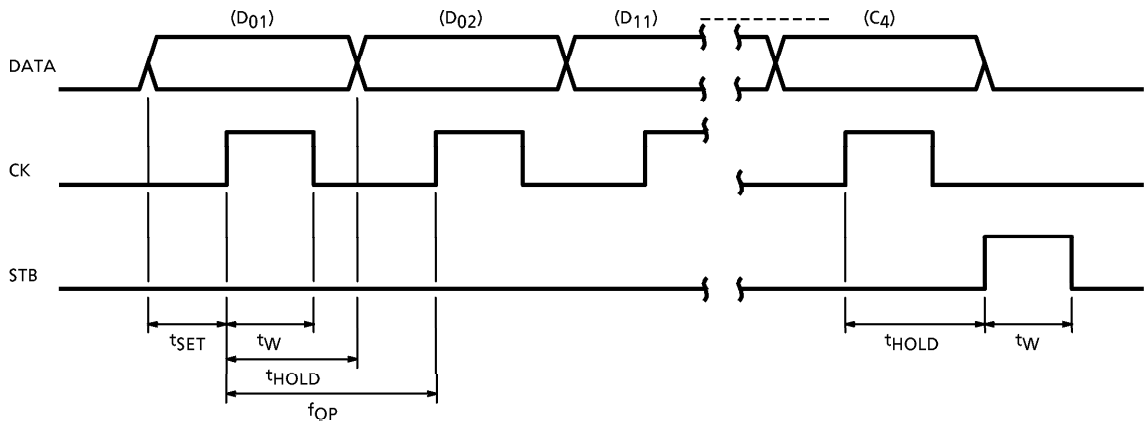
Step Resolution	$\Delta STEP$	—	0dB~4dB	0.5	1.0	1.5	dB
			4dB~16dB	1	2	3	
Output Load Resistance	R_L		F-OUT / R-OUT pins	12	33	—	$k\Omega$

● Overall characteristics

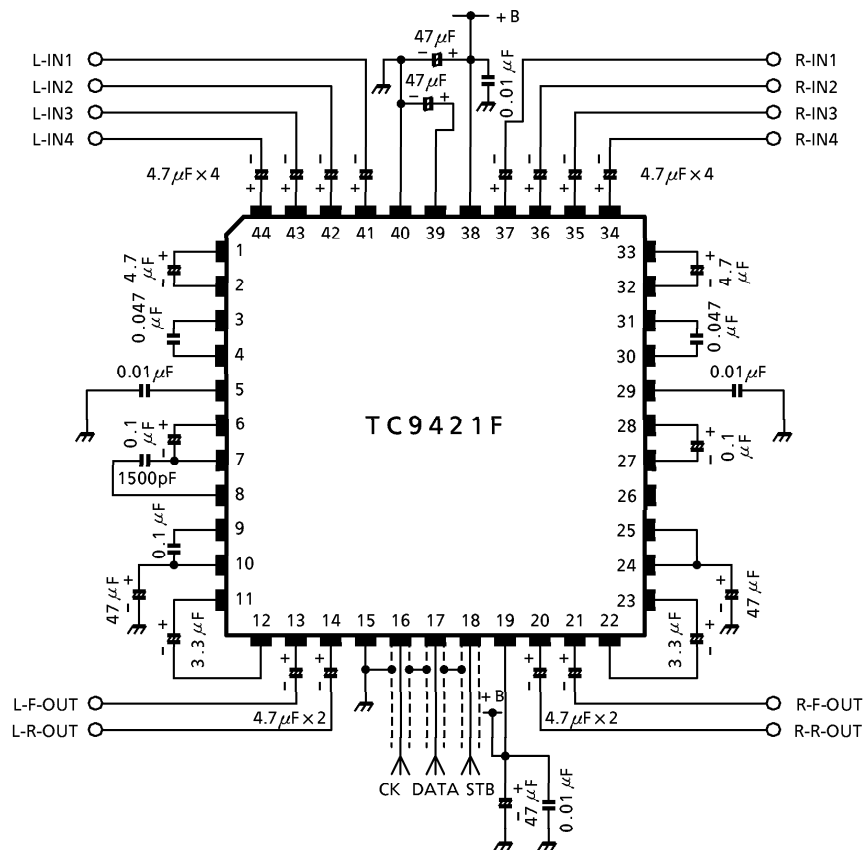
Overall Harmonic Distortion Ratio	THD (1)	1	$V_{IN} = 300mV_{rms}$ All set to flat $R_g = 600\Omega$ $R_L = 33k\Omega$	$f_{IN} = 1kHz$	—	0.005	0.01	%
	THD (2)			$f_{IN} = 20kHz$	—	0.008	0.02	
Crosstalk	TC		$V_{IN} = 1V_{rms}$, $R_g = 600\Omega$ $f_{IN} = 1kHz$, All set to flat		60	80	—	dB
Maximum Attenuation	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

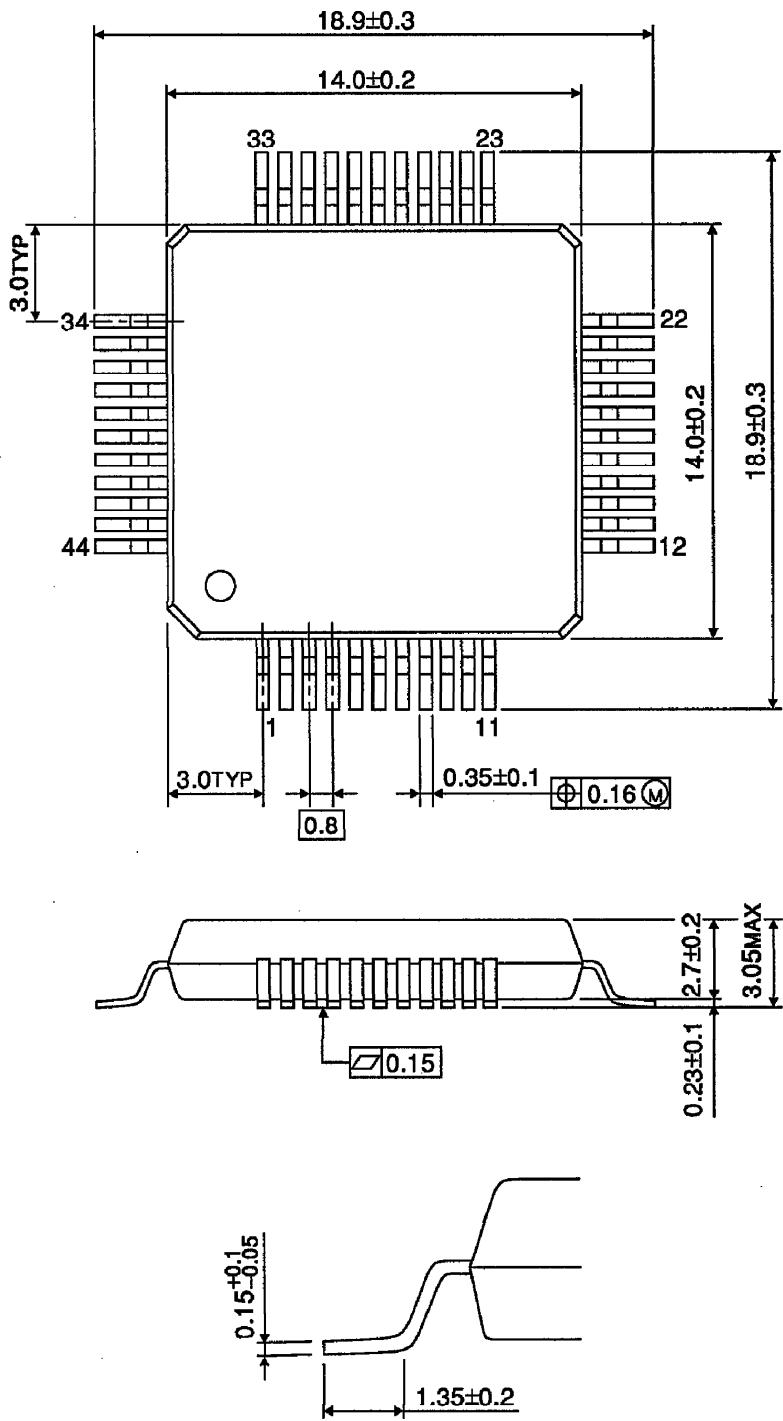


- The circuit example shows the left channel with loudness control and the right channel with no loudness control.

(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.

PACKAGE DIMENSIONS
QFP44-P-1414-0.80D

Unit : mm



Weight : 1.1g (Typ.)

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000707EBA

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