

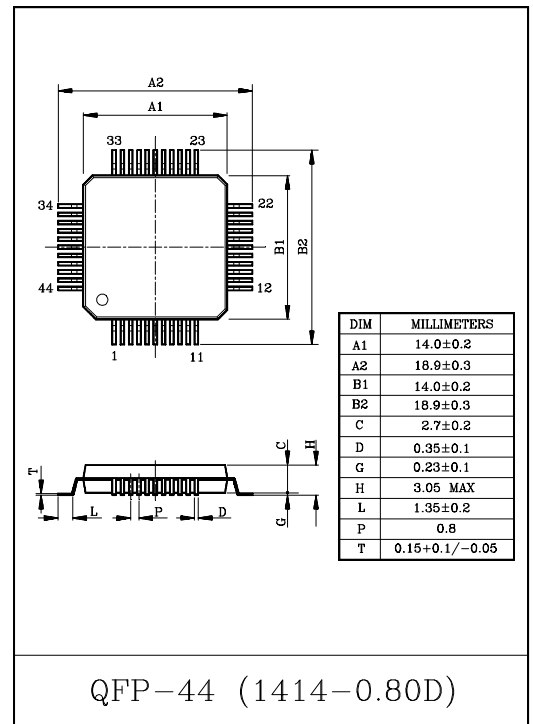
SYSTEM ELECTRONIC VOLUME

KIC9421F is a single-chip electronic volume IC incorporating an op amp circuit developed for car stereos.

With a few external parts, KIC9421F can control a wide range of audio functions, including main volume, balance, fader, bass, treble, loudness, and input switching.

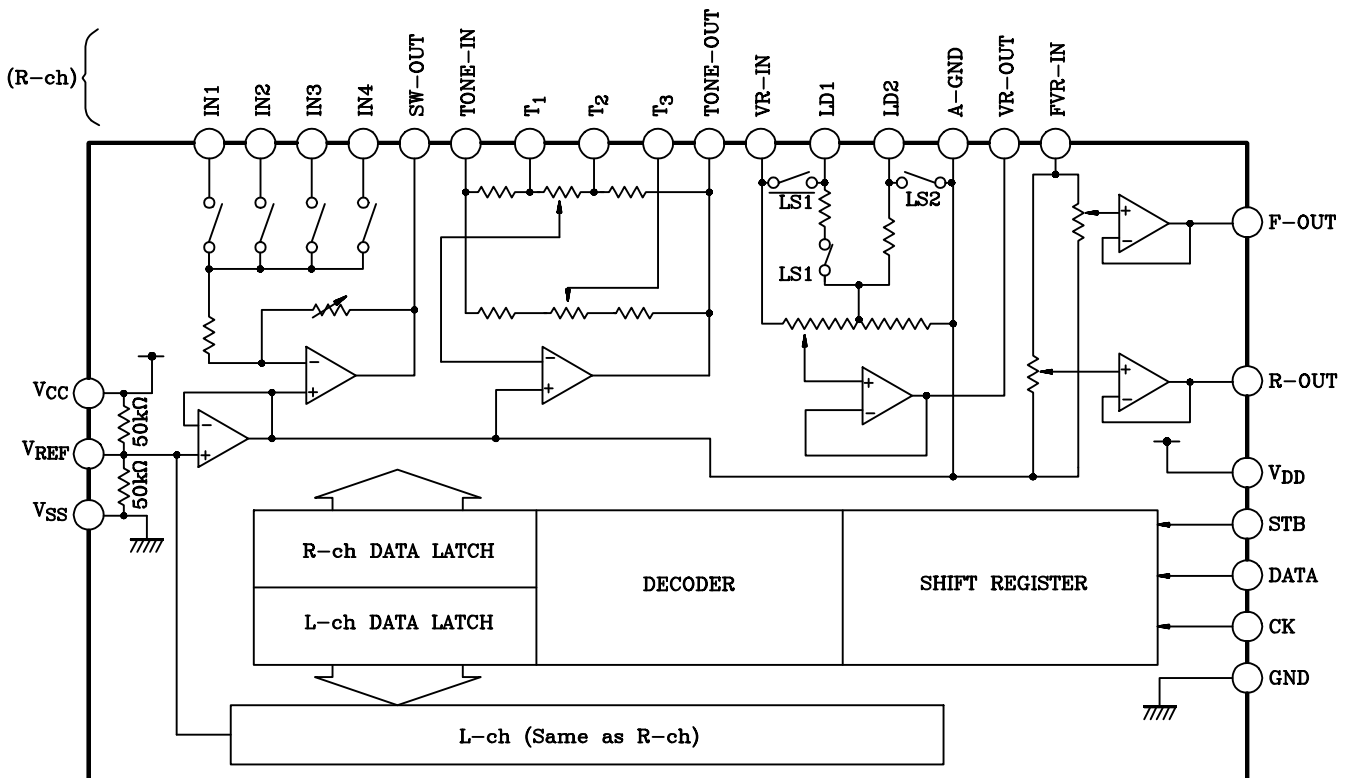
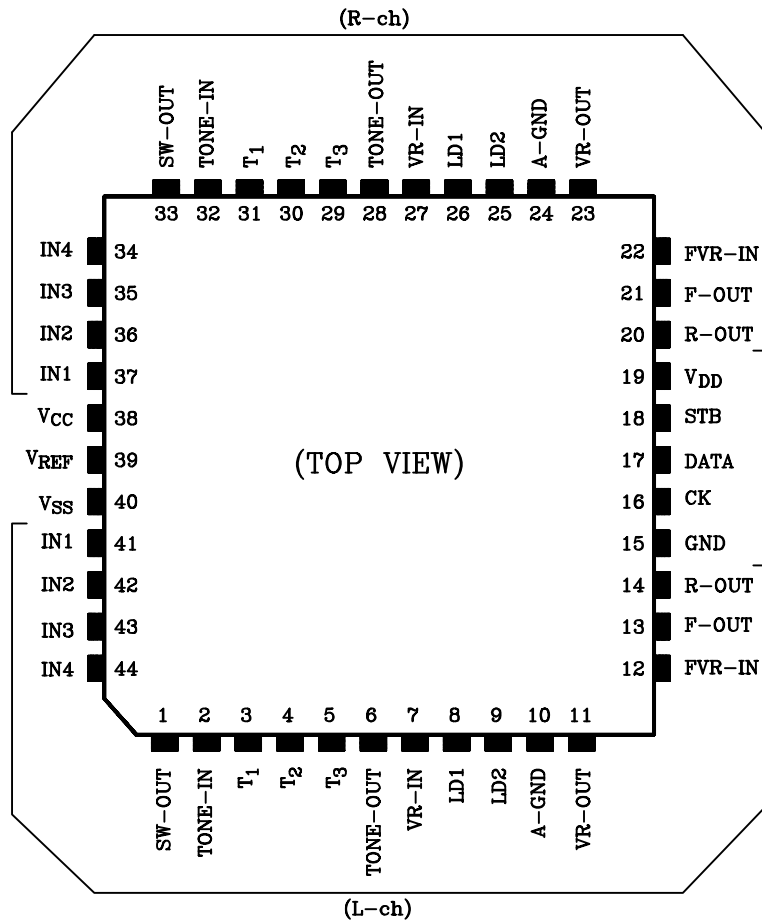
FEATURES

- 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.



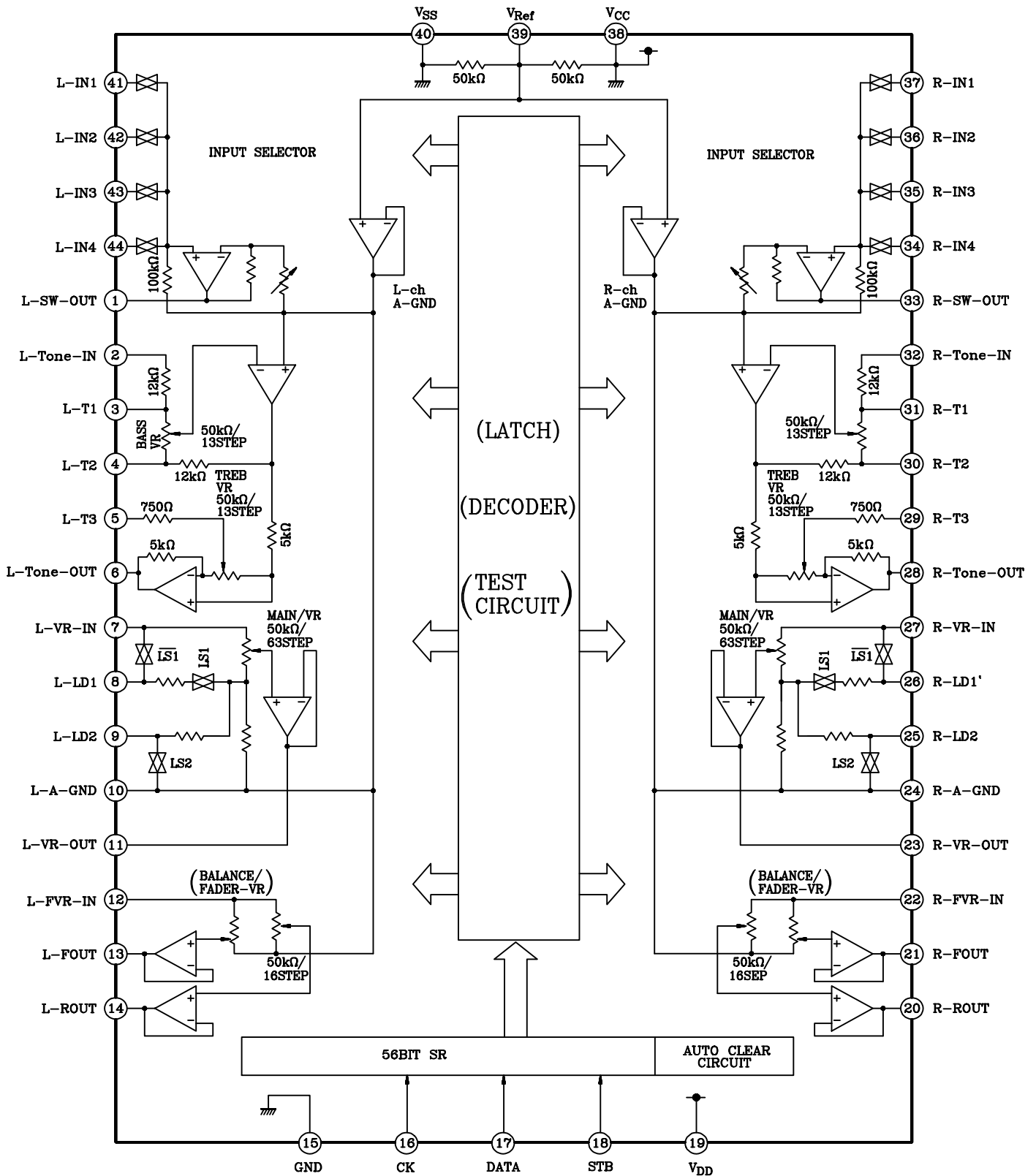
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PIN CONNECTION



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BLOCK DIAGRAM



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MAXIMUM RATINGS (Ta=25°C)

| CHARACTERISTIC | SYMBOL | RATING | UNIT |
|-----------------------------|-----------------|---------------------------|------|
| Power 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 Range | T_{opr} | -40~85 | °C |
| Storage Temperature Range | T_{stg} | -65~150 | °C |

ELECTRICAL CHARACTERISTICS

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

| CHARACTERISTIC | SYMBOL | TEST CIRCUIT | TEST CONDITION | MIN. | TYP. | MAX. | UNIT | |
|---------------------------|-----------------|--------------|--------------------------------------------|-----------------|------|----------|------------|---------|
| Operating Supply Voltage | V_{DD}/V_{CC} | - | $T_a=-40\sim 85^\circ C$ | 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 $V_{DD}=6.0\sim 12V$ | 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 | k Ω | |
| | 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} | | | - | - | 500 | | kHz |

Input Selector Block

| | | | | | | | | |
|---------------------|-------------|---|------------------------------------------------------|-----------|------|------|-----------|----|
| Maximum Input Level | V_{INMAX} | - | $f_{IN}=1kHz$, $G_V=0dB$ THD=1%, $R_L=12k\Omega$ | - | 2.0 | - | V_{rms} | |
| Input Gain | G_{V1} | | $f_{IN}=1kHz$ $R_g=600\Omega$ | $G_V=0dB$ | -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 | $\Delta STEP$ | - | 0dB~44dB | 0.5 | 1 | 1.5 | dB |
| | | | 44dB~78dB | 1 | 2 | 3 | |
| Output Load Resistance | R_L | - | VR-OUT pins | 12 | 25 | - | k Ω |

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Tone Control Block

| CHARACTERISTIC | SYMBOL | TEST CIRCUIT | 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

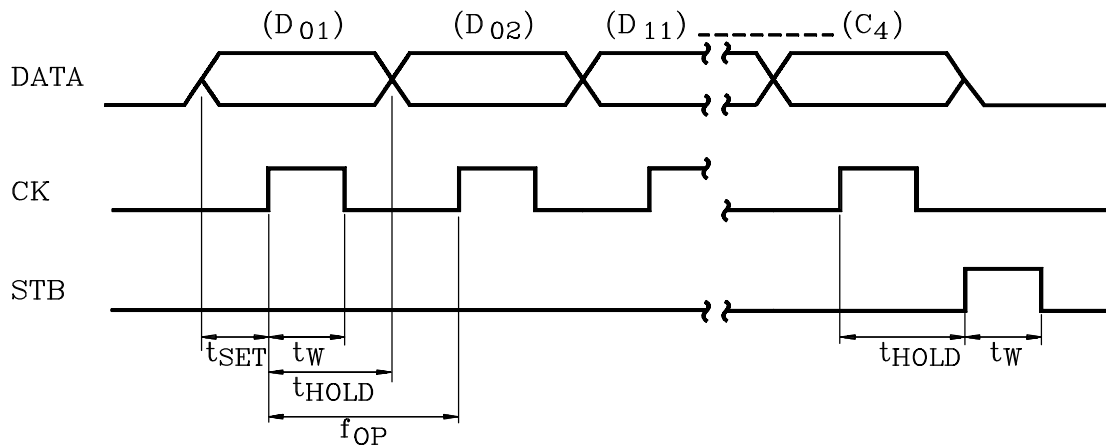
| | | | | | | | |
|------------------------|---------------|---|------------------|-----|-----|-----|------------|
| Step Resolution | $\Delta STEP$ | - | 0dB ~ 4dB | 0.5 | 1.0 | 1.5 | dB |
| | | | 4dB ~ 16dB | 1 | 2 | 3 | |
| Output Load Resistance | R_L | | F-OUT/R-OUT pins | 12 | 33 | - | k Ω |

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 | | | |

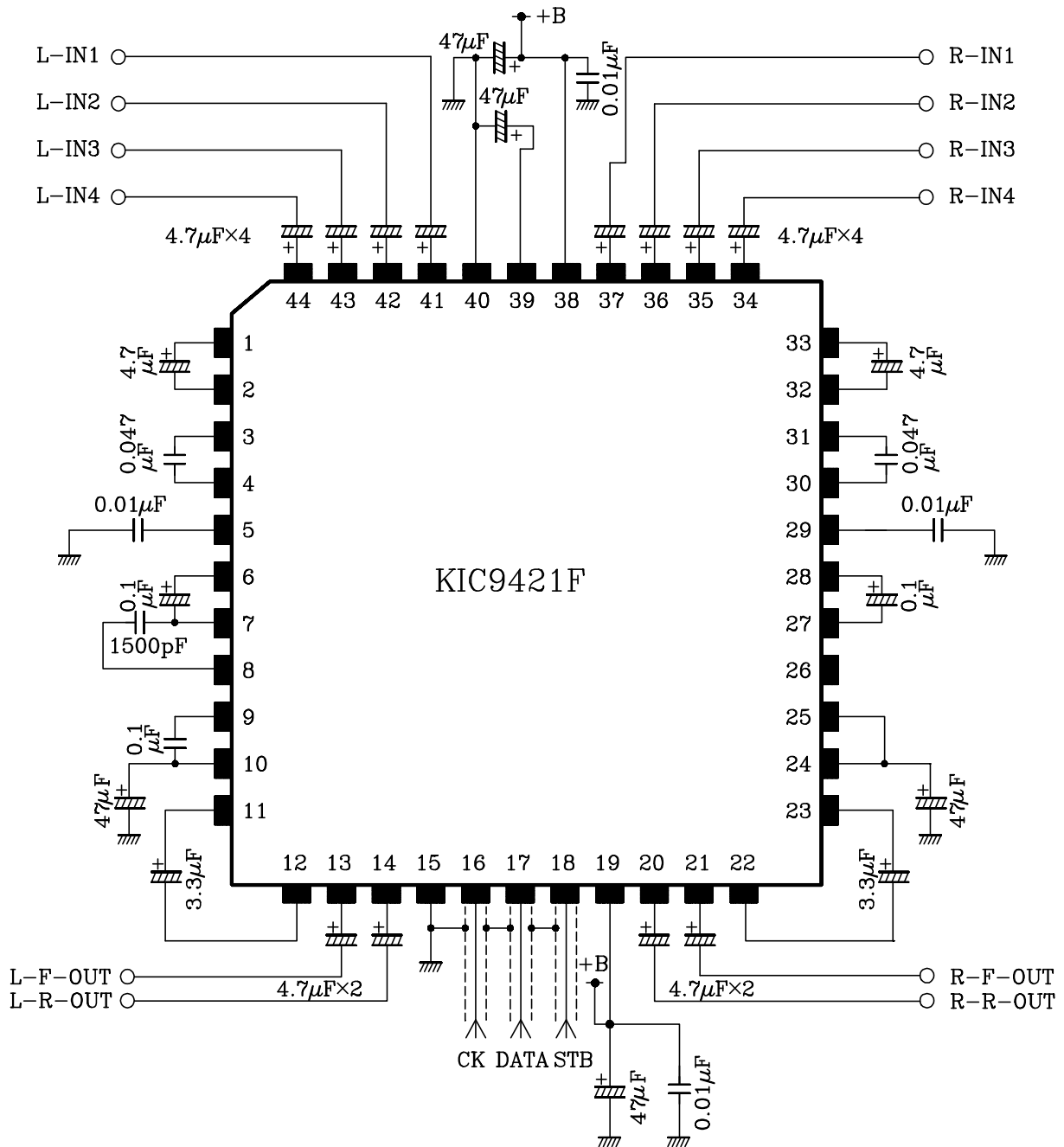
Test Circuit 1 : Application circuit example used

Test Circuit 2 : Serial data timing



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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.

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Description of Pins

| PIN NO. | SYMBOL | PIN NAME | FUNCTION AND OPERATION | REMARKS |
|---------|------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| 41 | L-IN1 | Audio signal input pins | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • Tone control circuit • Insert bass control capacitor between T₁ and T₂ • Insert treble control capacitor between T₁ (T₂) and T₃ • Supports 13-position control ($\pm 12\text{dB Typ.}$) | - |
| 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 | <ul style="list-style-type: none"> • 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 | - |
| 28 | R-TONE-OUT | | | |
| 7 | L-VR-IN | Main volume input pins | | |
| 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 | <ul style="list-style-type: none"> • 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 | <ul style="list-style-type: none"> • 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 | | | |

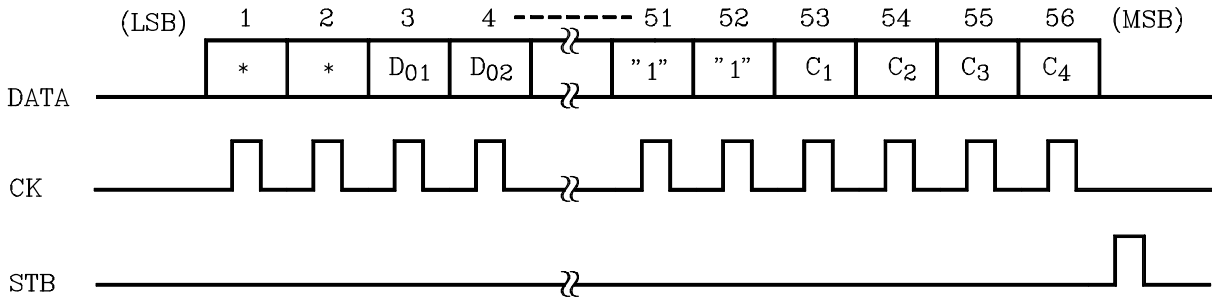
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| PIN NO. | SYMBOL | PIN NAME | FUNCTION AND OPERATION | REMARKS |
|---------|------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 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 | <ul style="list-style-type: none"> • 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

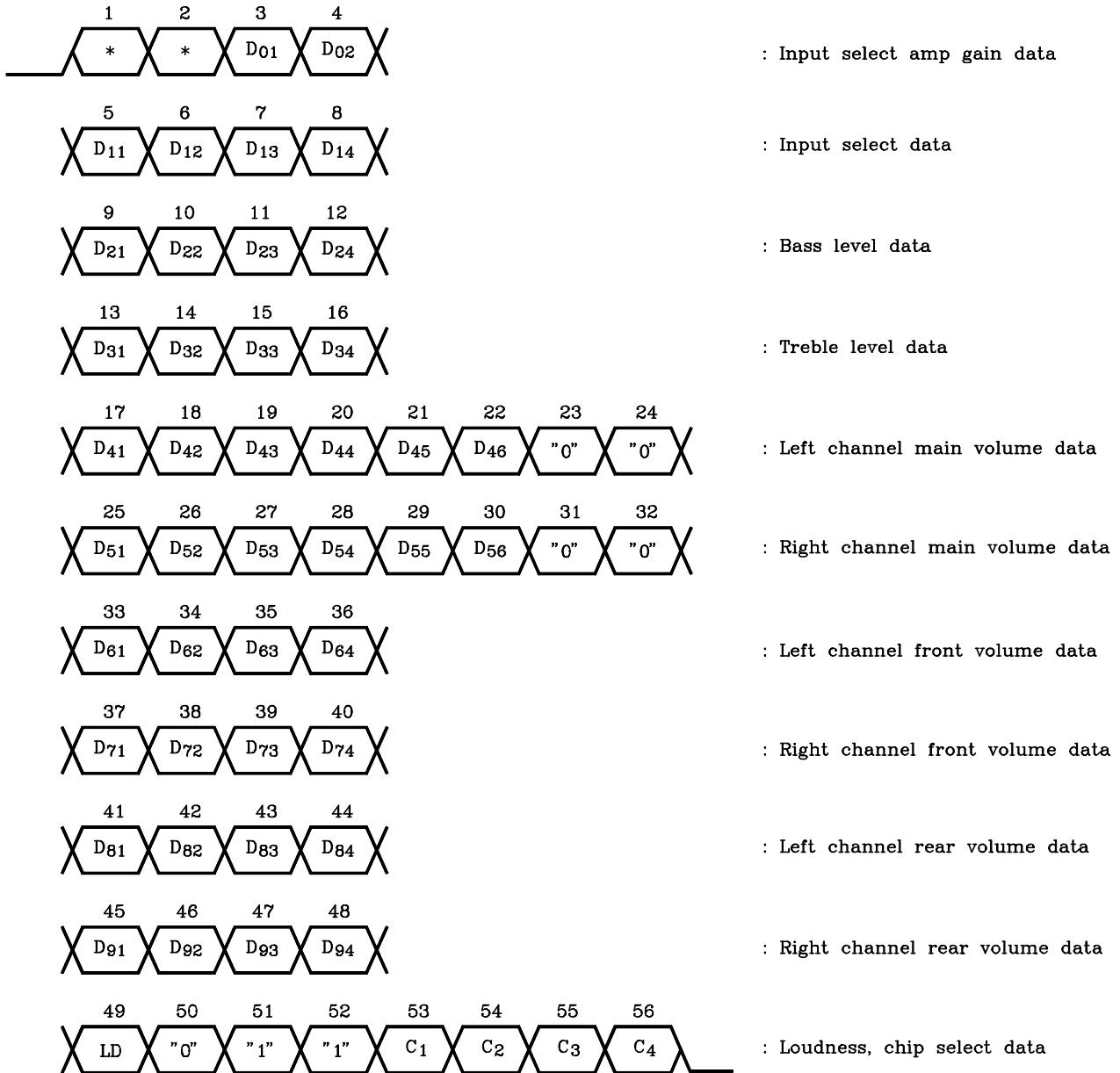
1. Volume data setting

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



KIC9421F

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



2) Chip select data (C₁~C₄)

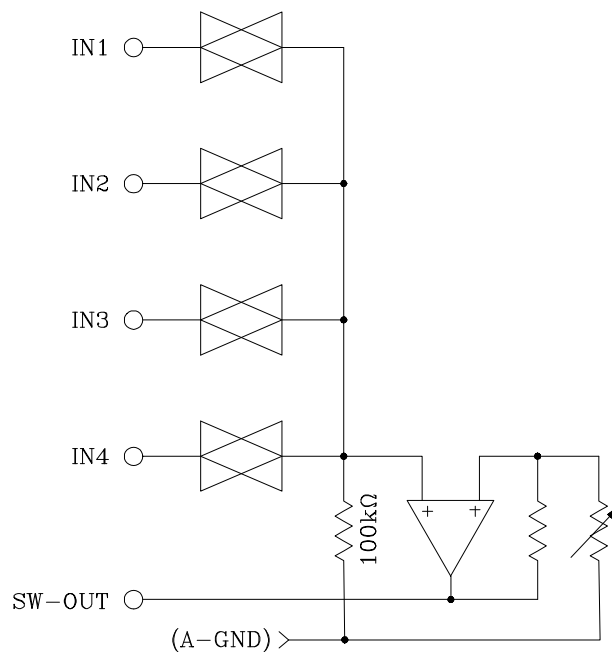
Chip select code to enable serial data line to be shared with other ICs.

For KIC9421F, set C₁="1", C₂=C₃="0", C₄="1" (1001:9H)

KIC9421F

2. Input select circuit

1) Equivalent circuit



2) Input select and gain settings

• Gain setting

| D _{O1} | D _{O2} | GAIN |
|-----------------|-----------------|------|
| 0 | 0 | 0dB |
| 1 | 0 | 6dB |
| 0 | 1 | 10dB |
| 1 | 1 | 12dB |

• Input select settings

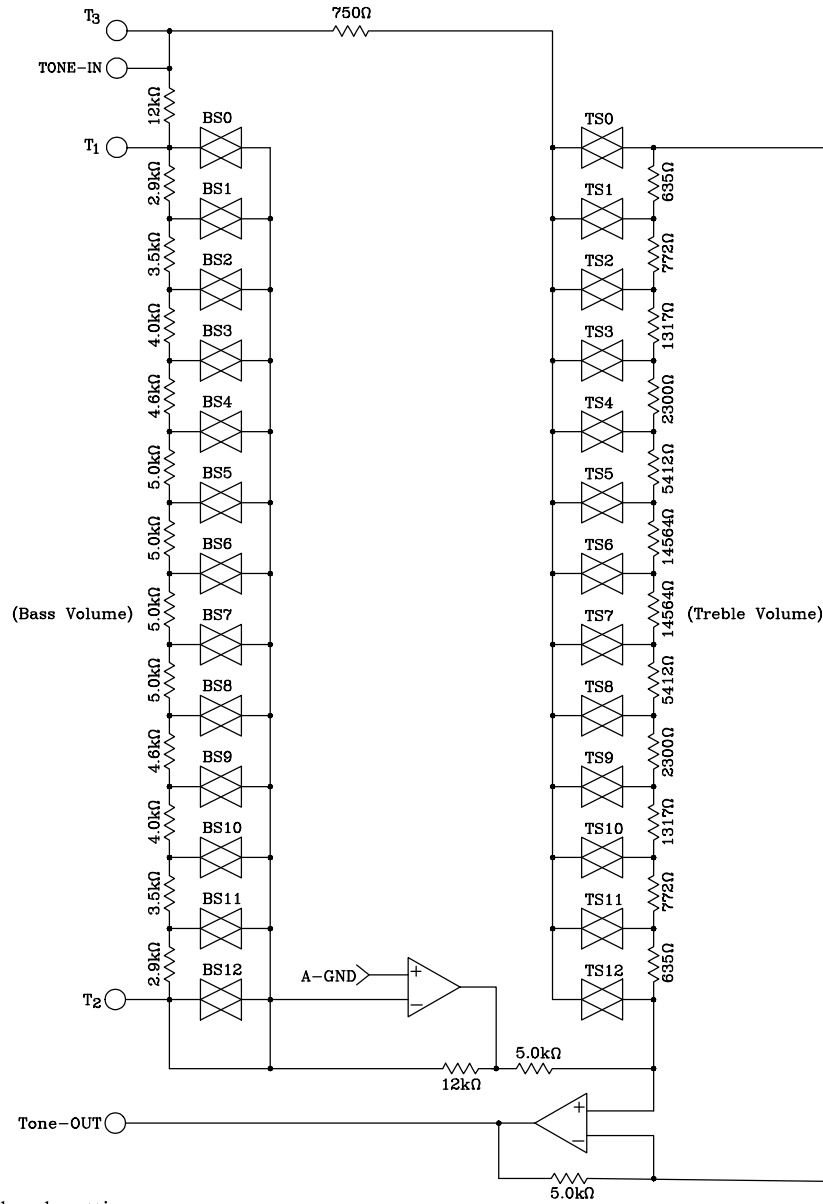
| D ₁₁ | D ₁₂ | D ₁₃ | D ₁₄ | SW ₁ | SW ₂ | SW ₃ | SW ₄ |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 0 | 0 | 0 | 0 | OFF | OFF | OFF | OFF |
| 1 | - | - | - | ON | - | - | - |
| - | 1 | - | - | - | ON | - | - |
| - | - | 1 | - | - | - | ON | - |
| - | - | - | 1 | - | - | - | ON |

(*) If turning on two or more among switches SW₁~SW₄ at the same time, connect 10kΩ or higher to the input pins (IN1~IN4).

KIC9421F

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 |

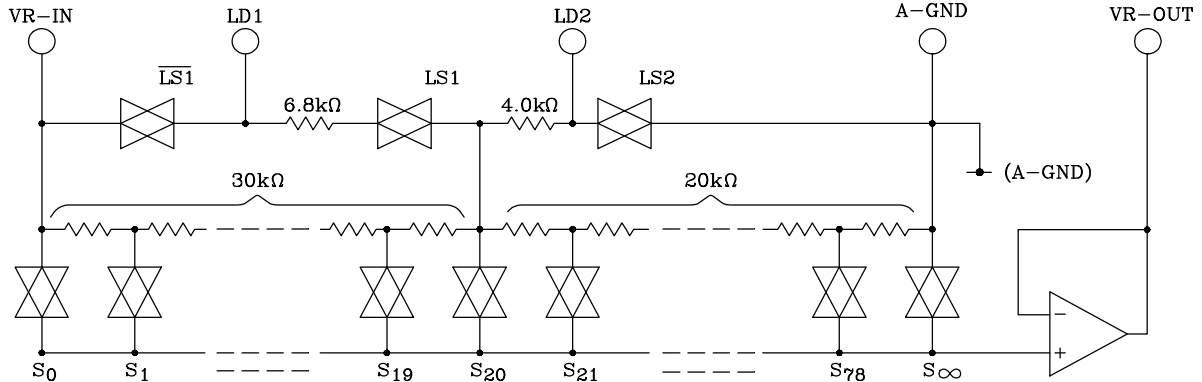
• Treble level settings

| 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 |

KIC9421F

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

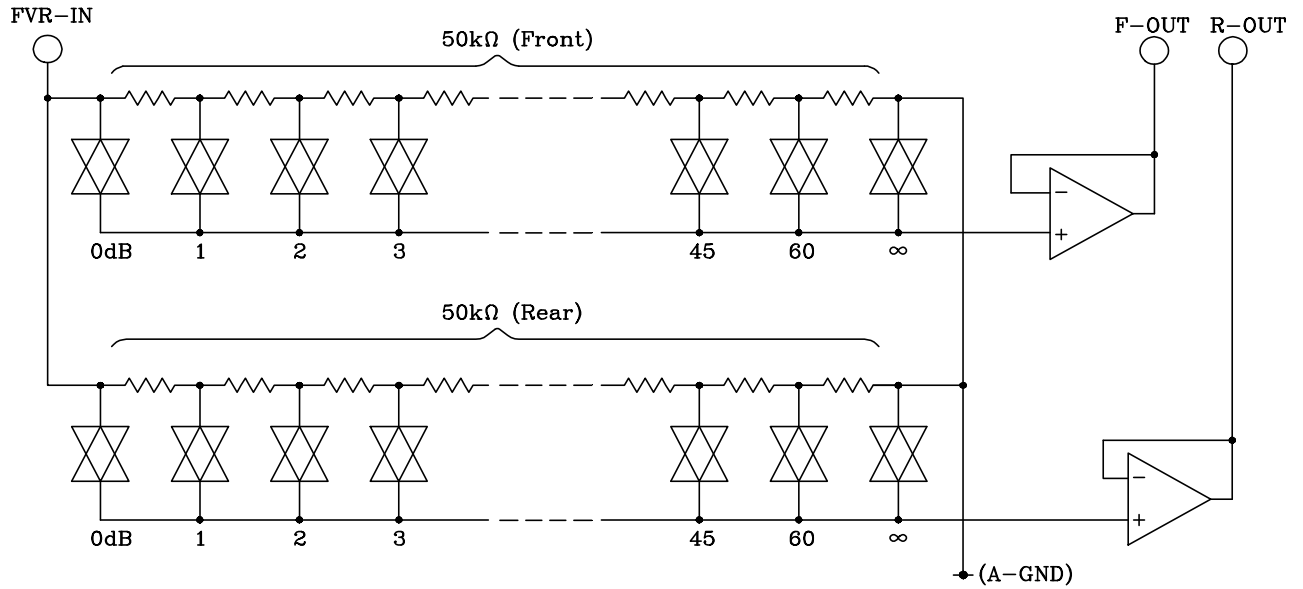
2) Main volume settings

| 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 | | | | | | | |

KIC9421F

5. Fader volume circuit

1) Equivalent circuit



2) Fader volume settings

• Front volume settings

| 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 settings

| 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 |