5.1ch Surround Processor

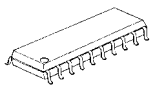
■ GENERAL DESCRIPTION

The **NJW1186** is an Surround Processor for 5.1ch speaker system regenarating Center, Surround and Subwoofer channel signal from normal stereo signal input. The **NJW1186** contains Passive Matrix circuit, BPF for center channel, LPF for subwoofer, simulated stereo function for surround channel and trimmers for each channel.

All of internal status and variables are controlled by I^2C BUS.

It is suitable for TV set, Home Theater and the others.

■ PACKAGE OUTLINE

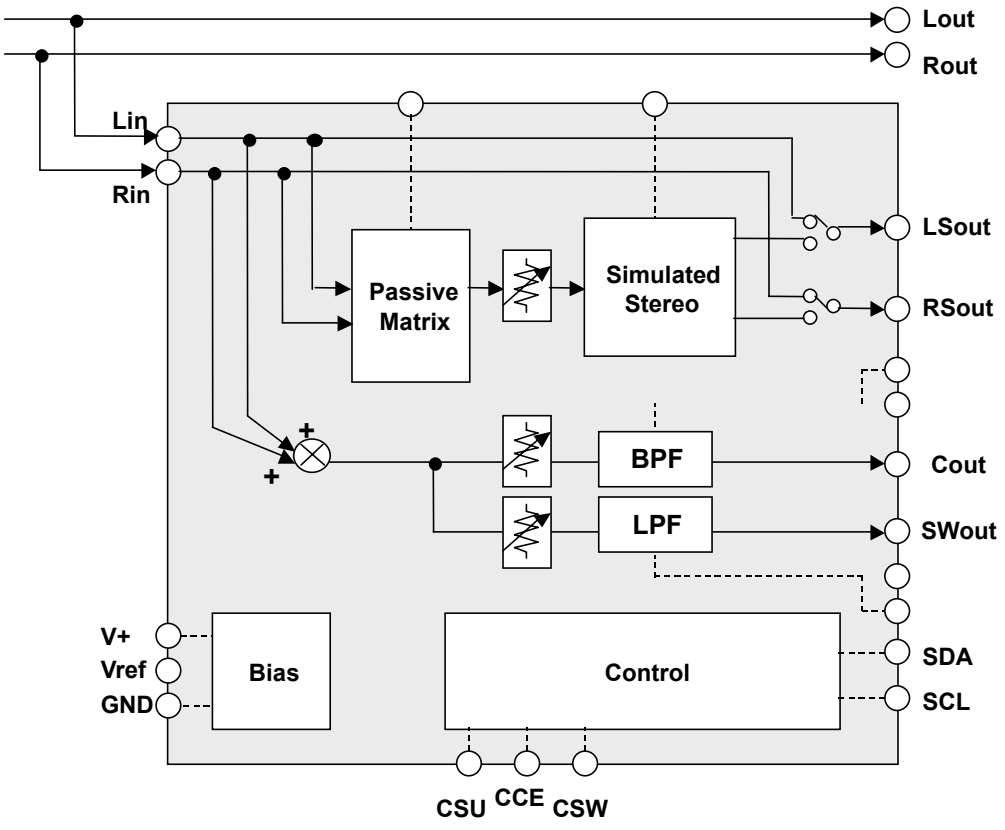


NJW1186M

■ FEATURES

- Operating Voltage 7.5 to 13V
- I^2C BUS Interface
- Passive Matrix Surround Circuit
- Trimmer & BPF for Center Channel
- Trimmer & LPF for Subwoofer Channel
- Trimmer & Simulated Stereo Function for Surround Channel
- Bi-CMOS Technology
- Package Outline DMP20

■ BLOCK DIAGRAM



■ **PIN CONFIGURATION**

No.	SYMBOL	FUNCTION
1	SWout	Subwoofer Channel Output
2	SWFilin	LPF for Subwoofer Channel
3	SW'out	Subwoofer Channel Trimmer Output
4	RSout	Right Surround Channel Output
5	Rin	Right Channel Input
6	Lin	Left Channel Input
7	LSout	Left Surround Channel Output
8	C'out	Center Channel Trimmer Output
9	CFilin	BPF for Center Channel
10	Cout	Center Channel Output
11	PS	Filter for Simulated Stereo
12	CSU	Pop Noise Reduction for Left Surround & Right Surround Channel Trimmer
13	SDA	I^2C Bus Data Input
14	SCL	I^2C Bus Clock Input
15	GND	Ground
16	V^+	Power Supply
17	Vrefin	Reference Voltage Stabilizing Capacitor
18	CCE	Pop Noise Reduction for Center Channel Trimmer
19	CSW	Pop Noise Reduction for Subwoofer Channel Trimmer
20	Filter	Filter for Surround Channel

■ ABSOLUTE MAXIMUM RATING (Ta=25°C)

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	V^+	15	V
Power Dissipation	P_D	350	mW
Maximum Input Voltage	V_{IM}	0 to V+	V
Operating Temperature Range	Topr	-40 to +85	°C
Storage Temperature Range	Tstg	-40 to +125	°C

■ RECOMMENDED OPERATING CONDITION

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Voltage	V^+	-	7.5	9.0	13.0	V

■ ELECTRICAL CHARACTERISTICS

(Ta=25°C, V+=9V, Rg=600Ω, R_L=47kΩ, SIM="0", SRSEL="1" unless otherwise specified)

♦Power Supply

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Current	I_{CC}	No Signal	-	6	10	mA
Reference Voltage	V_{REF}	No Signal	4.0	4.5	5.0	V

♦AC CHARACTERISTICS

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Input Impedance	Ri		-	24	-	kΩ

♦Center Channel Output (Lin=Rin=100mVrms, f=1kHz unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Maximum Input Voltage	V_{IMC}	THD=7%	2.8	3.0	-	Vrms
Voltage Gain	G_{VC}	BCC="0", C-TRIM="0000", C-MUTE="1"	-2.0	0	2.0	dB
Maximum Gain	G_{VMAXC}	BCC="1", C-TRIM="1111", C-MUTE="1"	12.5	15.0	17.5	
Minimum Gain	G_{VMINC}	BCC="0", C-TRIM="1111", C-MUTE="1"	-	-15.0	-	
Mute Level	G_{VMUTEC}	C-MUTE="0", Lin= 1Vrms, Rin=0	-	-80	-70	
Total Harmonic Distortion	THD_C	BCC="0", C-TRIM="0000", C-MUTE="1", BW=400Hz to 30kHz, Lin=Rin=500mVrms	-	0.1	0.5	%
Output Noise 1	V_{NO1C}	BCC="0", C-TRIM="0000", C-MUTE="1", No Signal, A-Weighted, Rg=0Ω	-	-94 (19.6)	-85 (56.2)	dBV (μVrms)
Output Noise 2	V_{NO2C}	C-MUTE="0", No Signal, A-Weighted, Rg=0Ω	-	-106 (5.0)	-96 (15.8)	

♦**Subwoofer Channel Output** (Lin=Rin=100mVrms, f=1kHz unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Maximum Input Voltage	V_{IMW}	THD=7%	2.8	3.0	-	Vrms
Voltage Gain	G_{VW}	BCW="0", W-TRIM="0000", W-MUTE="1"	-2.0	0	2.0	dB
Maximum Gain	G_{VMAXW}	BCW="1", W-TRIM="1111", C-MUTE="1"	12.5	15.0	17.5	
Minimum Gain	G_{VMINW}	BCW="0", W-TRIM="1111", W-MUTE="1"	-	-15.0	-	
Mute Level	G_{VMUTEW}	W-MUTE="0", Lin= 1Vrms, Rin=0	-	-80	-70	
Total Harmonic Distortion	THD_W	BCW="0", W-TRIM="0000", W-MUTE="1", BW=400Hz to 30kHz, Lin=Rin=500mVrms	-	0.1	0.5	%
Output Noise 1	V_{NO1W}	BCW="0", W-TRIM="0000", W-MUTE="1", No Signal, A-Weighted, Rg=0Ω	-	-94 (19.6)	-85 (56.2)	dBV (μVrms)
Output Noise 2	V_{NO2W}	W-MUTE="0", No Signal, A-Weighted, Rg=0Ω	-	-106 (5.0)	-96 (15.8)	

♦**Left Surround Channel Output** (Lin= 100mVrms, Rin=0, f=1kHz unless otherwise specified)

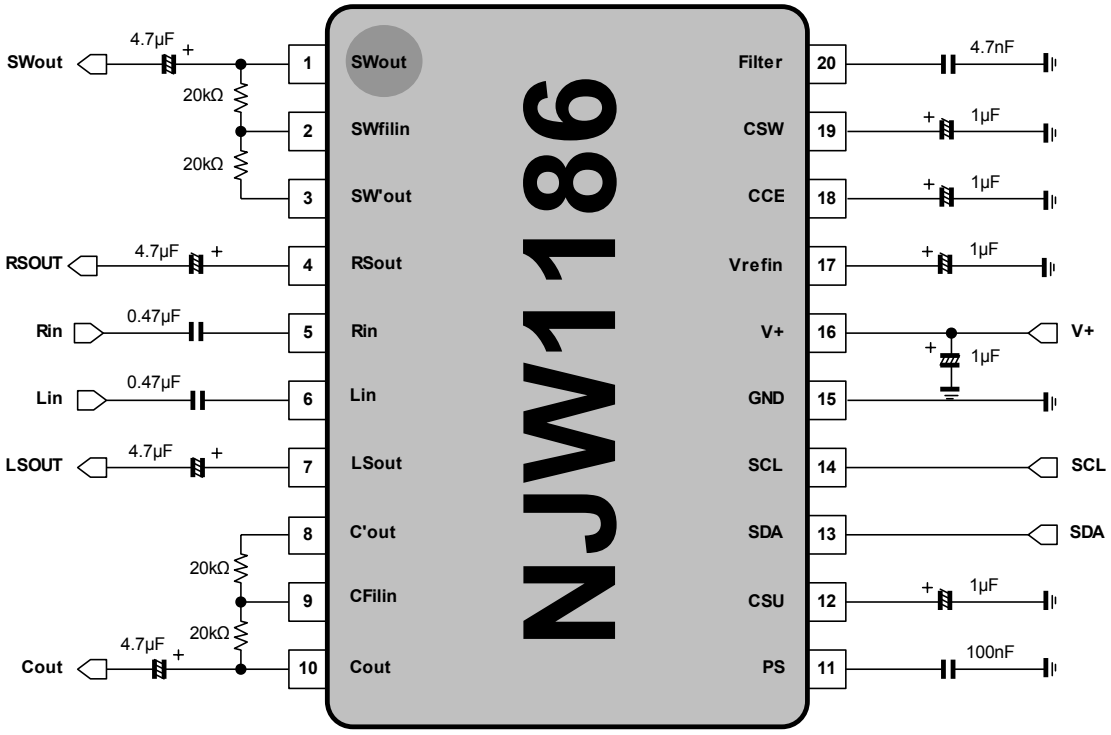
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Maximum Input Voltage	V_{IMLS}	THD=5%	2.8	3.0	-	Vrms
Bypass Gain	G_{VPASSL}	SRSEL=Bypass, Lin=Rin=100mVrms	-2.0	0	2.0	dB
Voltage Gain	G_{VLS}	BCS="0", S-TRIM="0000", S-MUTE="1", f=100Hz	-2.0	0	2.0	
Maximum Gain	G_{VMAXLS}	BCS="1", S-TRIM="1111", S-MUTE="1", f=100Hz	12.5	15.0	17.5	
Minimum Gain	G_{VMINLS}	BCS="0", S-TRIM="1111", S-MUTE="1", f=100Hz	-	-15.0	-	
Mute Level	$G_{VMUTELS}$	S-MUTE="0", Lin=1Vrms, Rin=0	-	-80	-70	
Total Harmonic Distortion	THD_{LS}	BCS="0", S-TRIM="0000", S-MUTE="1", BW=400Hz to 30kHz, Lin=500mVrms, Rin=0	-	0.1	0.5	%
Output Noise 1	V_{NO1LS}	BCS="0", S-TRIM="0000", S-MUTE="1", No Signal, A-Weighted, Rg=0Ω	-	-94 (19.6)	-85 (56.2)	dBV (μVrms)
Output Noise 2	V_{NO2LS}	S-MUTE="0", No Signal, A-Weighted, Rg=0Ω	-	-106 (5.0)	-96 (15.8)	

♦**Right Surround Channel Output** (Lin=0, Rin=100mVrms, f=1kHz unless otherwise specified)

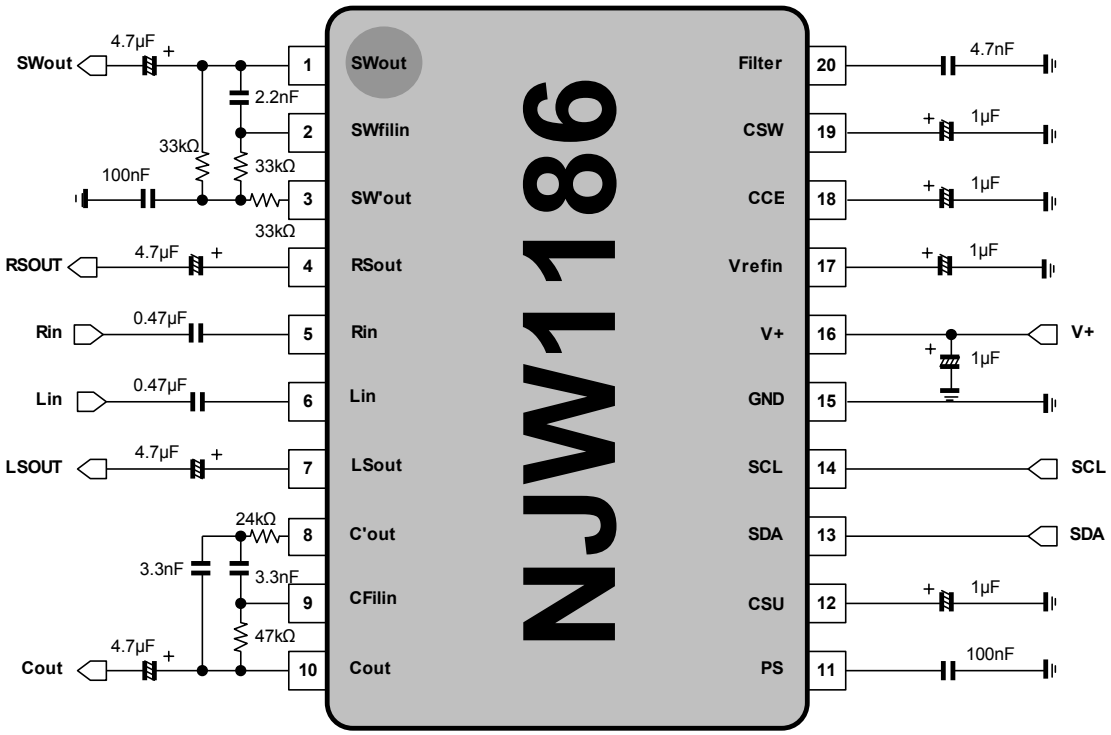
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Maximum Input Voltage	V_{IMRS}	THD=5%	2.8	3.0	-	Vrms
Bypass Gain	G_{VPASSR}	SRSEL=Bypass, Lin=Rin=100mVrms	-2.0	0	2.0	dB
Voltage Gain	G_{VRS}	BCS="0", S-TRIM="0000", S-MUTE="1", f=100Hz	-2.0	0	2.0	
Maximum Gain	G_{VMAXRS}	BCS="1", S-TRIM="1111", S-MUTE="1", f=100Hz	12.5	15.0	17.5	
Minimum Gain	G_{VMINRS}	BCS="0", S-TRIM="1111", S-MUTE="1", f=100Hz	-	-15.0	-	
Mute Level	$G_{VMUTERS}$	S-MUTE="0", Rin=1Vrms, Lin=0	-	-80	-70	
Total Harmonic Distortion	THD_{RS}	BCS="0", S-TRIM="0000", S-MUTE="1", BW=400Hz to 30kHz, Rin=500mVrms, Lin=0	-	0.1	0.5	%
Output Noise 1	V_{NO1RS}	BCS="0", S-TRIM="0000", S-MUTE="1", No Signal, A-Weighted, Rg=0Ω	-	-94 (19.6)	-85 (56.2)	dBV (μVrms)
Output Noise 2	V_{NO2RS}	S-MUTE="0", No Signal, A-Weighted, Rg=0Ω	-	-106 (5.0)	-96 (15.8)	

BW: Band Width

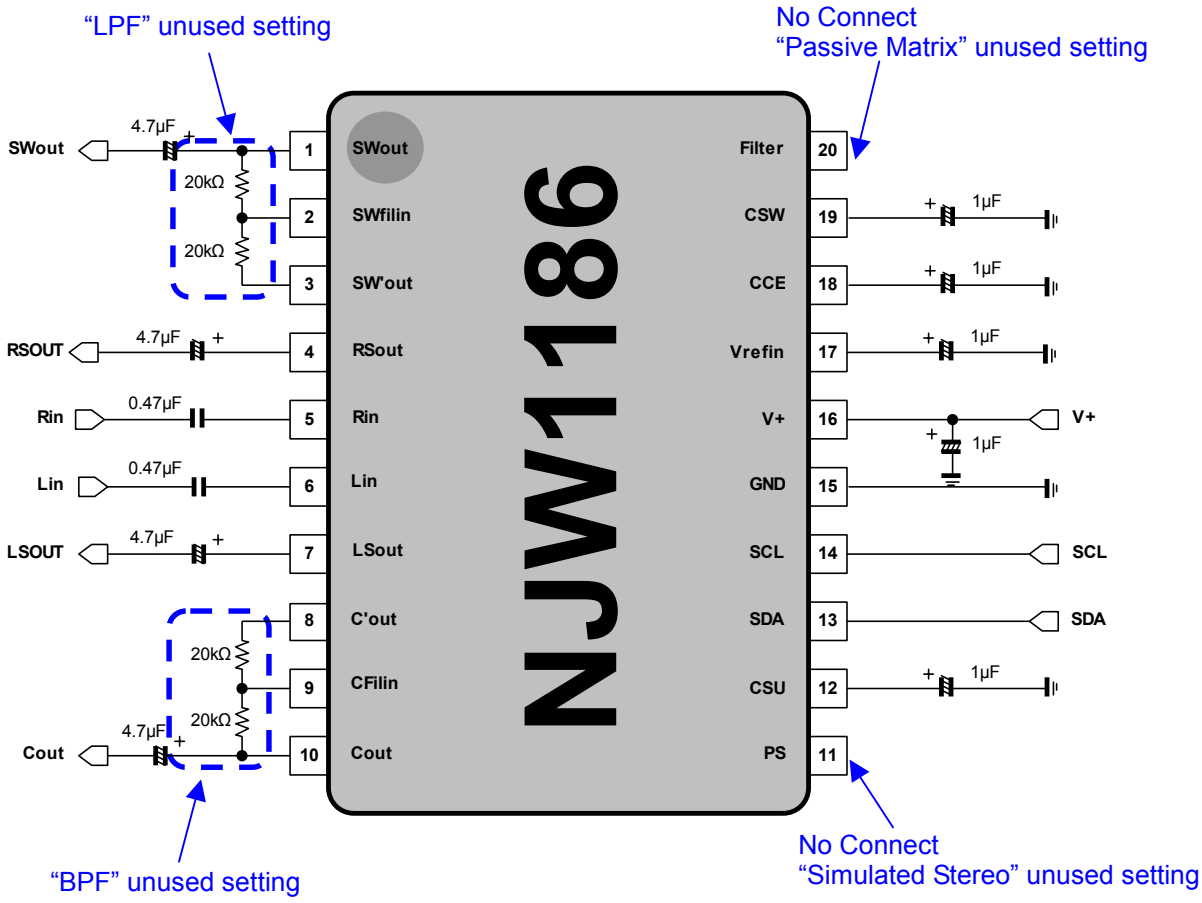
■ MEASUREMENT CIRCUIT



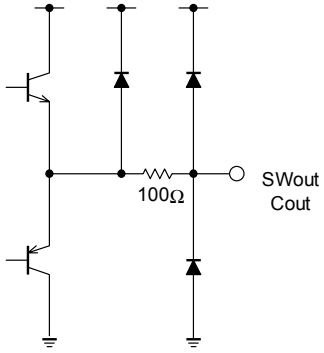
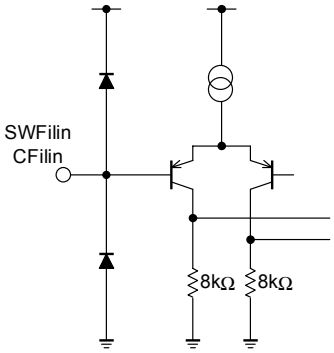
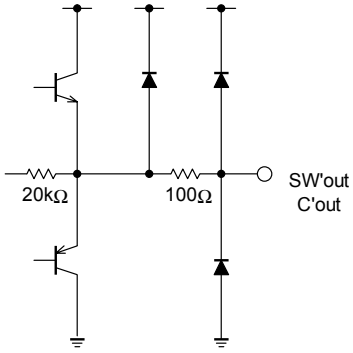
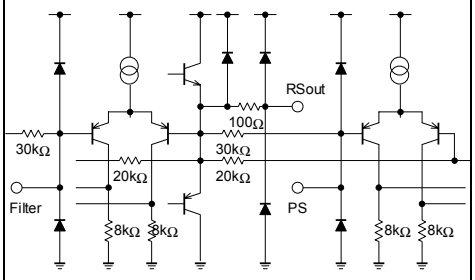
■ APPLICATION CIRCUIT 1



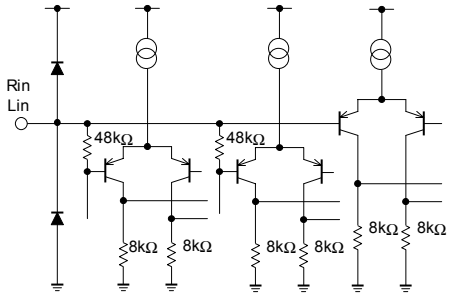
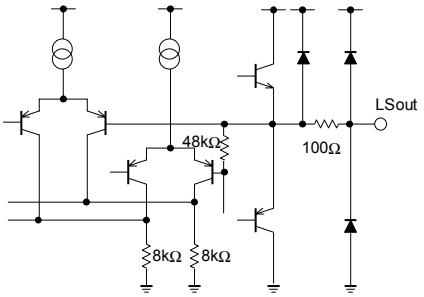
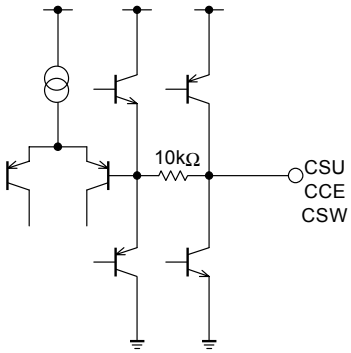
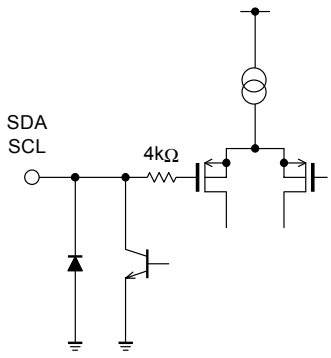
■ APPLICATION CIRCUIT 2



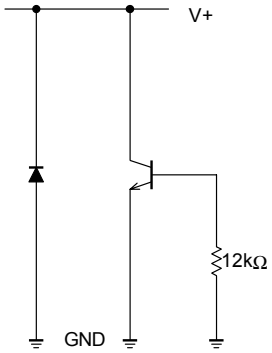
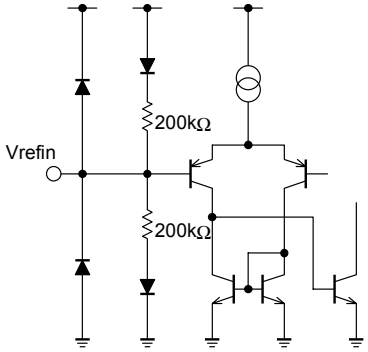
■ TERMINAL DESCRIPTION

PIN NO.	SYMBOL	FUNCTION	EQUIVALENT CIRCUIT	TERMINAL DC VOLTAGE
1 10	SWout Cout	Subwoofer Channel Output Center Channel Output		$V^+/2$
2 9	SWFilin CFilin	LPF for Subwoofer Channel LPF for Center Channel		-
3 8	SW'out C'out	Subwoofer Channel Trimmer Output Center Channel Trimmer Output		$V^+/2$
4 11 20	RSout PS Filter	Right Surround Channel Output Filter for Simulated Stereo Filter for Surround Channel		$V^+/2$

■ **TERMINAL DESCRIPTION**

PIN NO.	SYMBOL	FUNCTION	EQUIVALENT CIRCUIT	TERMINAL DC VOLTAGE
5 6	Rin Lin	Right Channel Input Left Channel Input		$V^+/2$
7	LSout	Left Surround Channel Output		$V^+/2$
12 18 19	CSU CCE CSW	Pop Noise Reduction for Left Surround & Right Surround Channel Trimmer Pop Noise Reduction for Center Channel Trimmer Pop Noise Reduction for Subwoofer Channel Trimmer		$V^+/2$
13 14	SDA SCL	I^2C Bus Data Input I^2C Bus Clock Input		-

■ **TERMINAL DESCRIPTION**

PIN NO.	SYMBOL	FUNCTION	EQUIVALENT CIRCUIT	TERMINAL DC VOLTAGE
15 16	GND V^+	Ground Power Supply		-
17	Vrefin	Reference Voltage Stabilizing Capacitor		$V^+/2$

■ DEFINITION OF I²C REGISTER

● I²C BUS FORMAT

	MSB LSB		MSB LSB		MSB LSB		MSB LSB		
S	Slave Address	A	Data (00H)	A	Data (01H)	A	Data (02H)	A	P
1bit	8bit	1bit	8bit	1bit	8bit	1bit	8bit	1bit	1bit

S: Starting Term
A: Acknowledge Bit
P: Ending Term

● SLAVE ADDRESS

MSB							LSB
1	0	0	0	0	0	0	R/W

R/$\overline{W}$=0: Write mode for register setting
R/$\overline{W}$=1: Not available

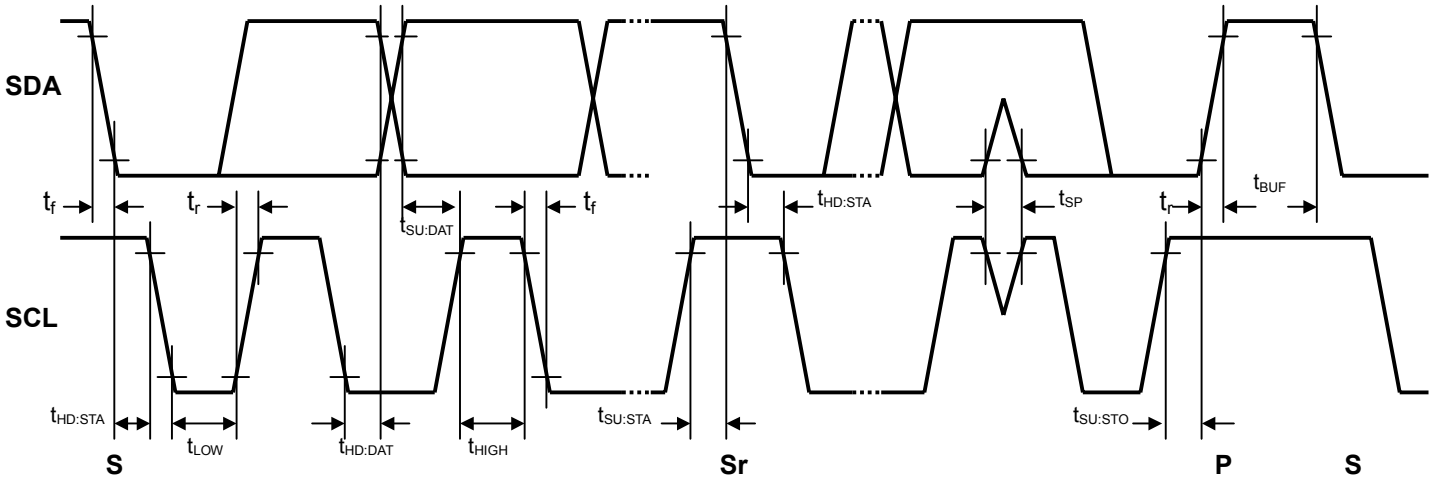
● CONTROL REGISTER TABLE

Address	BIT							
	D7	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**
00H	BCS	S-TRIM				S-MUTE	SIM	SRSEL
01H	BCC	C-TRIM				C-MUTE	Don't Care	
02H	BCW	W-TRIM				W-MUTE	Don't Care	

● CONTROL REGISTER DEFAULT VALUE

Address	BIT							
	D7	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**
00H	0	0	0	0	0	0	0	0
01H	0	0	0	0	0	0	-	
02H	0	0	0	0	0	0	-	

■TIMING ON THE I^2C BUS (SDA,SCL)



■CHARACTERISTICS OF I/O STAGES FOR I^2C BUS (SDA,SCL)

I^2C BUS Load Conditions

STANDARD MODE : Pull up resistance 4kΩ (Connected to +5V), Load capacitance 200pF (Connected to GND)

FAST MODE : Pull up resistance 4kΩ (Connected to +5V), Load capacitance 50pF (Connected to GND)

PARAMETER	SYMBOL	Standard mode			Fast mode			UNIT
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Low Level Input Voltage	V_{IL}	0.0	-	1.5	0.0	-	1.5	V
High Level Input Voltage	V_{IH}	2.7	-	5.0	2.7	-	5.0	V
Low level output voltage (3mA at SDA pin)	V_{OL}	0	-	0.4	0	-	0.4	V
Input current each I/O pin with an input voltage between $0.1V_{DD}$ and $0.9V_{DDmax}$	I_i	-10	-	10	-10	-	10	μA

■CHARACTERISTICS OF BUS LINES (SDA,SCL) FOR I²C-BUS DEVICES

PARAMETER	SYMBOL	Standard mode			Fast mode			UNIT
		MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
SCL clock frequency	f_{SCL}	-	-	100	-	-	400	kHz
Hold time (repeated) START condition.	$t_{HD:STA}$	4.0	-	-	0.6	-	-	μs
Low period of the SCL clock	t_{LOW}	4.7	-	-	1.3	-	-	μs
High period of the SCL clock	t_{HIGH}	4.0	-	-	0.6	-	-	μs
Set-up time for a repeated START condition	$t_{SU:STA}$	4.7	-	-	0.6	-	-	μs
Data hold time NOTE)	$t_{HD:DAT}$	0	-	-	0	-	-	μs
Data set-up time	$t_{SU:DAT}$	250	-	-	100	-	-	ns
Rise time of both SDA and SCL signals	t_r	-	-	1000	-	-	300	ns
Fall time of both SDA and SCL signals	t_f	-	-	300	-	-	300	ns
Set-up time for STOP condition	$t_{SU:STO}$	4.0	-	-	0.6	-	-	μs
Bus free time between a STOP and START condition	t_{BUF}	4.7	-	-	1.3	-	-	μs
Capacitive load for each bus line	C_b	-	-	400	-	-	400	pF
Noise margin at the Low level	V_{nL}	0.5	-	-	0.5	-	-	V
Noise margin at the High level	V_{nH}	1	-	-	1	-	-	V

C_b ; total capacitance of one bus line in pF.

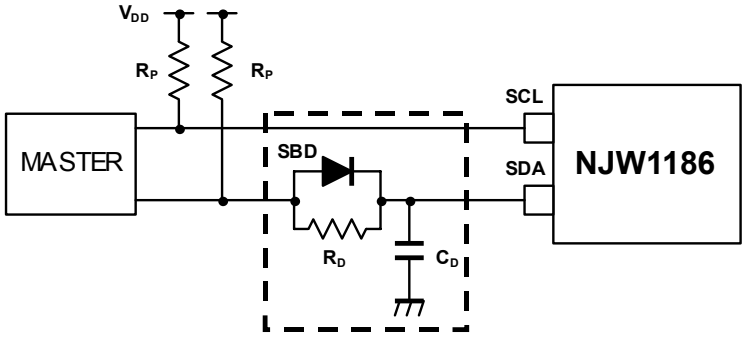
NOTE). Data hold time : $t_{HD:DAT}$

Please hold the Data Hold Time ($t_{HD:DAT}$) to 300ns or more to avoid status of unstable at SCL falling edge.

The SDA block in the NJW1186 does not hold data. Add external data-delay-circuit of the SDA terminal, in case of not providing a hold time of at least 300nsec for the SDA in the master device.
The time-consists of the data-delay-circuit of the SDA terminal are as follows.

(a) Low level → High level : $T_{LH} \approx R_P * C_D$
(b) High level → Low level : $T_{HL} \approx R_D * C_D$

In addition, Schottky barrier diode (SBD) influences a Low level at the Acknowledge. Therefore choose the low forward voltage (Vf) as much as possible.



■ I²C CONTROL COMMAND DESCRIPTION

a) SURROUND CHANNEL SETTINGS

Address	BIT							
	D7	D6	D5	D4	D3	D2	D1	D0
00H	BCS	S-TRIM				S-MUTE	SIM	SRSEL

- BCS: Boost or Cut Select for Surround Channel Trimmer
  - "0": Cut
  - "1": Boost
- S-TRIM: Trimmer Level for Surround Channel
  - Cut Level : -15 to 0dB(1dB/step)
  - Boost Level : 0 to +15dB(1dB/step)
- S-MUTE: Mute for Surround Channel Trimmer
  - "0": Mute ON
  - "1": Mute OFF
- SIM: Simulated Stereo Function for Surround Channel
  - "0": Normal
  - "1": Wide
- SRSEL: Surround Channel Signal Selector
  - "0": Bypass (The output signal as same as L/Rch input signal.)
  - "1": Surround Settings

b) CENTER CHANNEL SETTINGS

Address	BIT							
	D7	D6	D5	D4	D3	D2	D1	D0
01H	BCC	C-TRIM				C-MUTE	Don't Care	

- BCC: Boost or Cut Select for Center Channel Trimmer
  - "0": Cut
  - "1": Boost
- C-TRIM: Trimmer Level for Center Channel
  - Cut Level : -15 to 0dB(1dB/step)
  - Boost Level : 0 to +15dB(1dB/step)
- C-MUTE: Mute for Center Channel Trimmer
  - "0": Mute ON
  - "1": Mute OFF

c) SUBWOOFER CHANNEL SETTINGS

Address	BIT							
	D7	D6	D5	D4	D3	D2	D1	D0
02H	BCW	W-TRIM				W-MUTE	Don't Care	

- BCW: Boost or Cut Select for Subwoofer Channel Trimmer
  - "0": Cut
  - "1": Boost
- W-TRIM: Trimmer Level for Subwoofer Channel
  - Cut Level : -15 to 0dB(1dB/step)
  - Boost Level : 0 to +15dB(1dB/step)
- W-MUTE: Mute for Subwoofer Channel Trimmer
  - "0": Mute ON
  - "1": Mute OFF

■ SURROUND CHANNEL TRIMMER SETTINGS (Address: 00H)

Trimmer Cut or Boost	BCS
	D7
Cut	0
Boost	1

		S-TRIM			
Cut Gain(dB)	Boost Gain(dB)	**D6**	**D5**	**D4**	**D3**
-15	15	1	1	1	1
-14	14	1	1	1	0
-13	13	1	1	0	1
-12	12	1	1	0	0
-11	11	1	0	1	1
-10	10	1	0	1	0
-9	9	1	0	0	1
-8	8	1	0	0	0
-7	7	0	1	1	1
-6	6	0	1	1	0
-5	5	0	1	0	1
-4	4	0	1	0	0
-3	3	0	0	1	1
-2	2	0	0	1	0
-1	1	0	0	0	1
0	0	0	0	0	0

■ CENTER CHANNEL TRIMMER SETTINGS (Address: 01H)

Trimmer Cut or Boost	BCC
	D7
Cut	0
Boost	1

		C-TRIM			
Cut Gain(dB)	Boost Gain(dB)	**D6**	**D5**	**D4**	**D3**
-15	15	1	1	1	1
-14	14	1	1	1	0
-13	13	1	1	0	1
-12	12	1	1	0	0
-11	11	1	0	1	1
-10	10	1	0	1	0
-9	9	1	0	0	1
-8	8	1	0	0	0
-7	7	0	1	1	1
-6	6	0	1	1	0
-5	5	0	1	0	1
-4	4	0	1	0	0
-3	3	0	0	1	1
-2	2	0	0	1	0
-1	1	0	0	0	1
0	0	0	0	0	0

■ **SUBWOOWER CHANNEL TRIMMER SETTINGS (Address: 02H)**

Trimmer Cut or Boost	BCW **D7**
Cut	0
Boost	1

		W-TRIM			
Cut Gain(dB)	Boost Gain(dB)	**D6**	**D5**	**D4**	**D3**
-15	15	1	1	1	1
-14	14	1	1	1	0
-13	13	1	1	0	1
-12	12	1	1	0	0
-11	11	1	0	1	1
-10	10	1	0	1	0
-9	9	1	0	0	1
-8	8	1	0	0	0
-7	7	0	1	1	1
-6	6	0	1	1	0
-5	5	0	1	0	1
-4	4	0	1	0	0
-3	3	0	0	1	1
-2	2	0	0	1	0
-1	1	0	0	0	1
0	0	0	0	0	0

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