



Dolby Pro Logic II / Virtual Dolby Surround Decoder

■ General Description

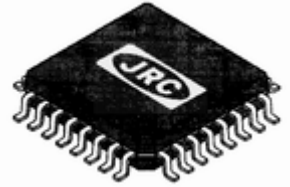
The NJU26106 is a digital audio signal decoder that provides the function of Dolby Pro Logic II and Virtual Dolby Surround.

The NJU26106 processes the stereo matrix-encoded signal into spacious sound of 5.1 channels by Dolby Pro Logic II and Bass Management System. Also not matrix-encoded audio signal can be processed into effective spacious sound by Music mode.

The decoded 5-channel signal can be downmixed into 2-channel virtual surround output by the Dolby Virtual technology.

The applications of the NJU26106 are suitable for multi-channel products such as AV AMP and Car Audio, or ordinary audio products such as small speaker system.

■ Package



NJU26106

■ FEATURES

- 5.1 Channel signal outputs by Dolby Pro Logic II
- 2 Channel outputs by Virtual Dolby Surround
- Movie mode / Music mode
- Available for center width control, dimension control, panorama mode Music mode and Custom mode
- Two kinds of micro computer interface
 - I²C Bus (standard-mode/100Kbps)
 - 4-Wire Serial Bus (4-Wire: clock, enable, input data, output data)

■ Digital Signal Processor Specification

- 24bit Fixed-point Digital Signal Processing
- Maximum Clock Frequency : 40MHz
- Digital Audio Interface : 2 Input ports / 3 Output ports
- Power Supply : DSP Core : 2.5V I/O interface: 2.5V(+3.3V tolerant)
I/O interface: 2.5V(+3.3V tolerant)
- Package : QFP 32pin

* Note1: The Word "DOLBY", "Pro Logic" and the double D mark are trademarks of Dolby Laboratories.

The NJU26106 can only be delivered to licensees of Dolby Laboratories.

Please refer to the licensing application manual issued by Dolby Laboratories.

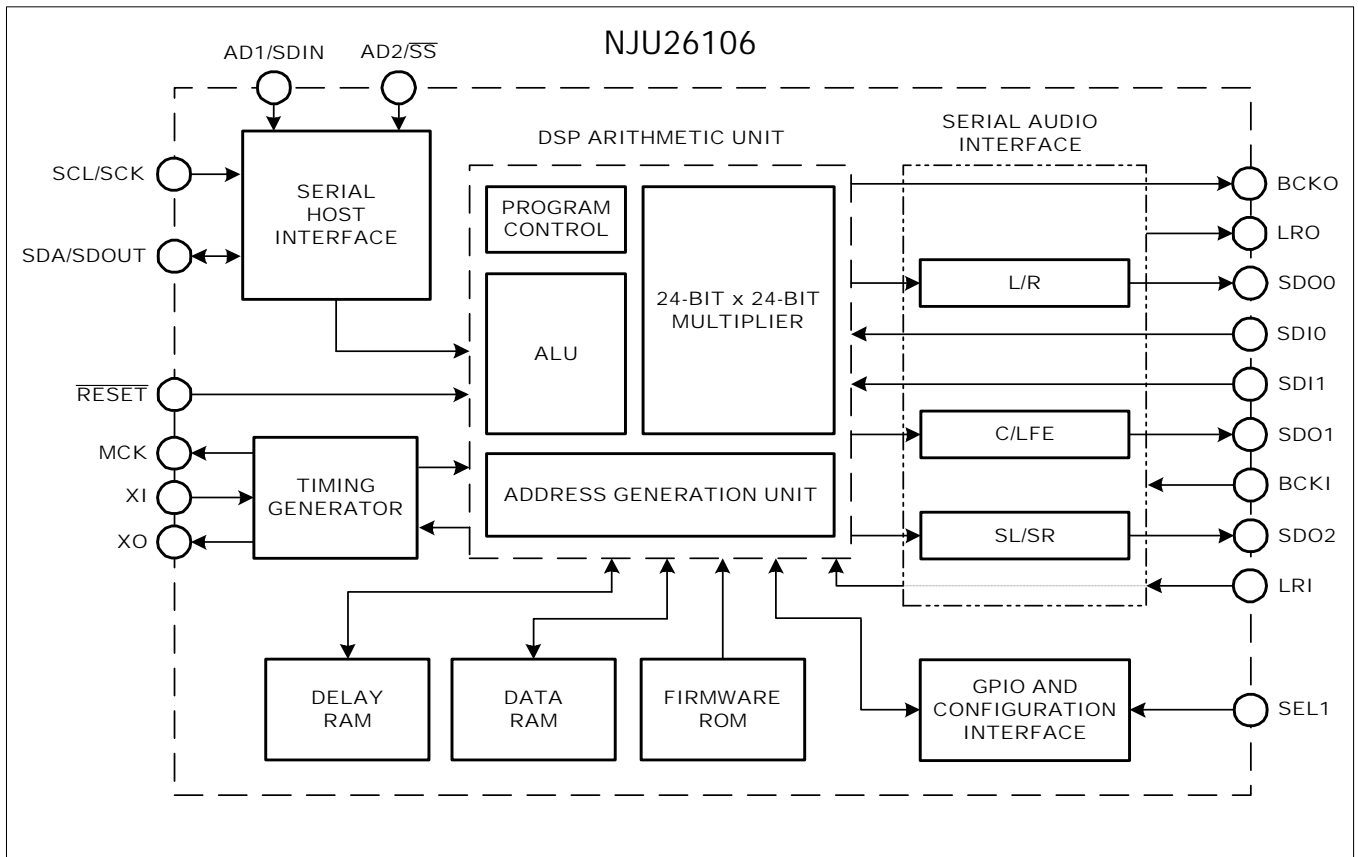
* Note2: Purchase of I²C components of New Japan Radio Co., Ltd or one of sublicensed Associated Companies

conveys a license under the Philips I²C Patent Rights to use these components in an I²C system,

provided that the system conforms to the I²C Standard specification as defined by Philips.

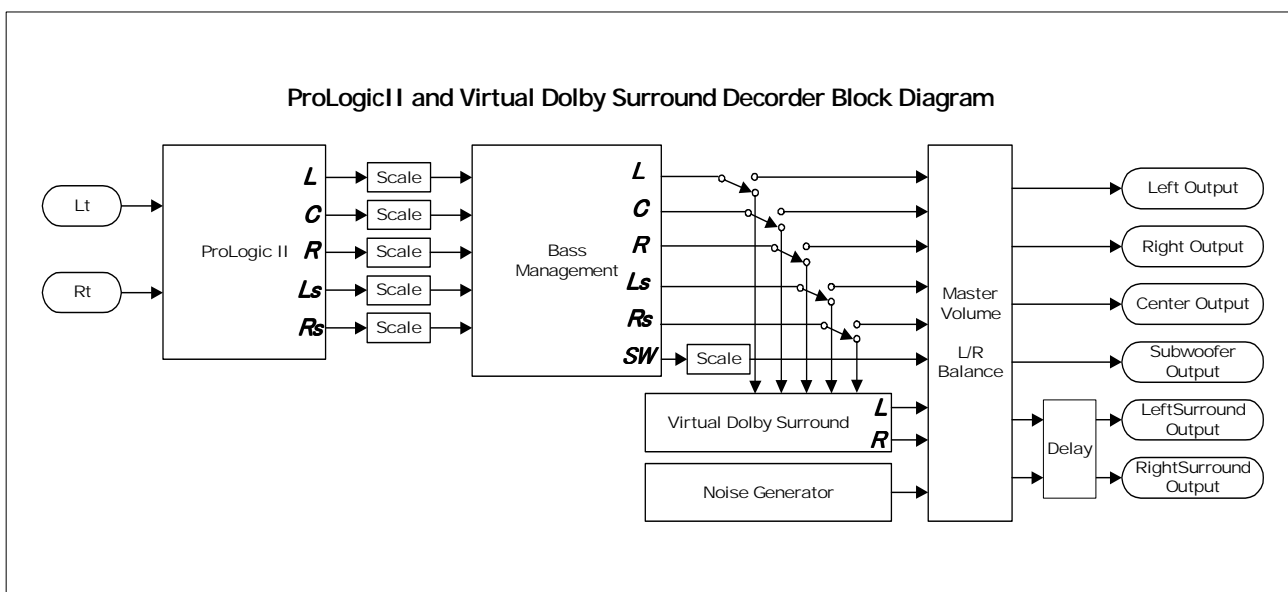
■ DSP Block Diagram

Fig.1-1 NJU26106 Block Diagram

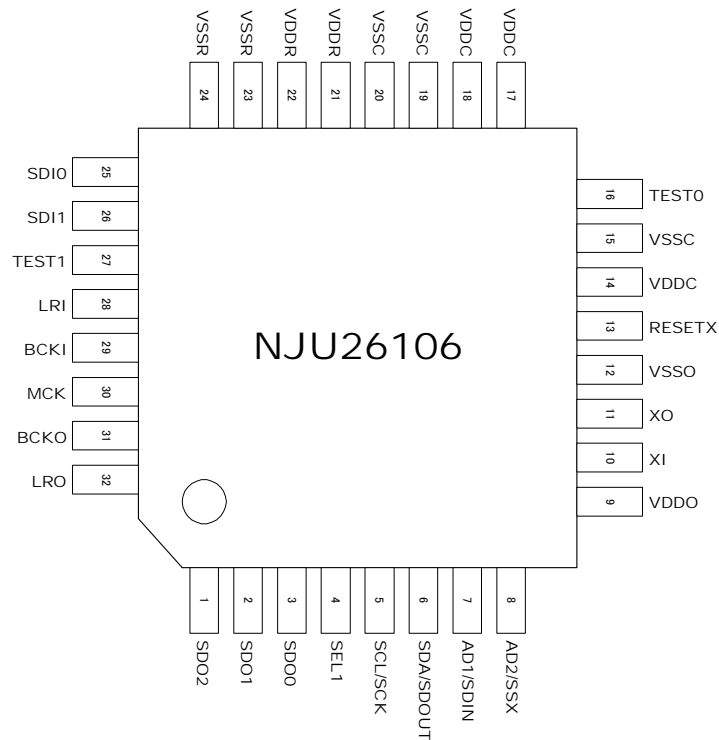


■ Pro Logic II & Virtual Dolby Surround Decoder

Fig.1-2 NJU26106 Function Diagram



Pin Configuration



Pin Description

Table1-1 Pin Description

No.	Symbol	I/O	Description	No.	Symbol	I/O	Description
1	SDO2	O	Audio Data Output CH2	17	VDDC	P	Core Power Supply +2.5V
2	SDO1	O	Audio Data Output CH1	18	VDDC	P	Core Power Supply +2.5V
3	SDO0	O	Audio Data Output CH0	19	VSSC	G	Core GND
4	SEL1	I	Select I ² C or Serial bus	20	VSSC	G	Core GND
5	SCL/SCK	I	I ² C Clock / Serial Clock	21	VDDR	P	I/O Power Supply +2.5V
6	SDA/SDOUT	IO	I ² C I/O / Serial Output	22	VDDR	P	I/O Power Supply +2.5V
7	AD1/SDIN	I	I ² C Address / Serial Input	23	VSSR	G	I/O GND
8	AD2/SSX	I	I ² C Address / Serial Enable	24	VSSR	G	I/O GND
9	VDDO	P	OSC Power Supply +2.5V	25	SDI_0	I	Audio Data Input CH0
10	XI	I	X'tal Clock Input	26	SDI_1	I	Audio Data Input CH1
11	XO	O	X'tal Clock Output	27	TEST3	I	GND
12	VSSO	G	OSC GND	28	LRI	I	LR Clock Input
13	RESETX	I	RESET	29	BCKI	I	Bit Clock Input
14	VDDC	P	Core Power Supply +2.5V	30	MCK	O	Master Clock Output
15	VSSC	G	Core GND	31	BCKO	O	Bit Clock Output
16	TEST2	IO	OPEN	32	LRO	O	LR Clock Output

* I:In, O:Out, IO:Bidir, P:+Power, G:GND

■ Absolute Maximum Ratings

Table1-2 Absolute Maximum Ratings

Parameter	Symbol	Rating	Units
Supply Voltage	V_{DD}	3.05	V
Pin No.10(Xi) Input Voltage	$V_{X(OSC)}$	-0.3~3.05	V
Input,Output Pin Voltage	V_x	-0.3~3.6	V
Power Dissipation	P_D	0.3	W
Operating Temperature *	T_{OPR}	-20~+75	°C
Storage Temperature	T_{stg}	-40~+125	°C

* For the car application, please ask NJR sale.

■ Electric Characteristics

Table1-3 Electric Characteristics ($V_{DD}=2.5V, T_a=25^\circ C$)

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Units
Operating V_{DD} Voltage	V_{DD}	V_{DD} pins	2.25	2.5	2.75	V
Operating Current	I_{DD}	$f_{OSC}=36.864MHz$	-	60	-	mA
Recommended Operating Temperature	T_{OPRR}	$V_{DD}=2.5V$	0	25	70	°C
High Level Input Voltage(Xi)	$V_{IH(OSC)}$	No.10pin(Xi) Only	2.0	-	V_{DD}	V
High Level Input Voltage	V_{IH}		2.0	-	3.3	V
Low Level Input Voltage	V_{IL}		V_{SS}	-	0.5	V
High Level Input Current	I_{IH}	$V_{IN}=3.3V$	-10	-	+10	μA
High Level Input Current	$I_{IH(pd)}$	$V_{IN}=3.3V$	100	-	300	μA
Low Level Input Current	I_{IL}	$V_{IN}=V_{SS}$	-10	-	+10	μA
High Level Output Voltage	V_{OH}	$I_{OH}=-2mA$	$V_{DD}-0.4$	-	-	V
Low Level Output Voltage	V_{OL}	$I_{OL}=2mA$	-	-	0.4	V
Input Capacitance	C_{IN}		-	5	-	pF
Input Rise/Fall transition Time	t_r / t_f	except for No.5, 6, 7, 8pin *	-	-	100	ns
Clock Frequency	f_{OSC}	No.10pin(Xi)	-	-	38.0	MHz
Ext.System Clock Duty Cycle	r_{EC}	No.10pin(Xi)	47.5	50	52.5	%

* The t_r / t_f of these terminals is specified separately.

* All input / input-and-output terminals serve as the Schmidt trigger input except for No.10pin(Xi).

1. Clock and Reset

The NJU26106 Xi pin requires the system clock that should be related to the sample frequency f_s . The Xi/Xo pins can generate the system clock by connecting the crystal oscillator or the ceramic resonator. Refer to the application circuit diagram about the circuit parameters.

When the external oscillator is connected to Xi/Xo pins, check the voltage level of the pins. Because the maximum input voltage level of Xi pin is different from the other input or bi-directional pins. The maximum voltage-level of Xi pin equals to VDD.

To initialize the NJU26106, RESET pin should be set low level during some period. After some period of Low level, RESET pin should be High level. This procedure starts the initialization of the NJU26106. To finalize the initialization procedure takes 1 m sec. After 1 m sec, the NJU26106 can accept a command from Host controller. The detail status of the initialized NJU26106 is referred to the each command that describes the initial status.

To select I²C bus or 4-Wire serial bus, some level should be supplied to SEL1 pin. When SEL1="L", I²C bus is selected. When SEL1="H", 4-Wire serial bus is selected. The level of SEL1 is checked by the NJU26106 in 1 m sec after RESET-pin level goes to "H". After the power supply and the oscillation of the NJU26106 becomes stable, RESET pin should be kept Low-level at least t_{RESETX} period.

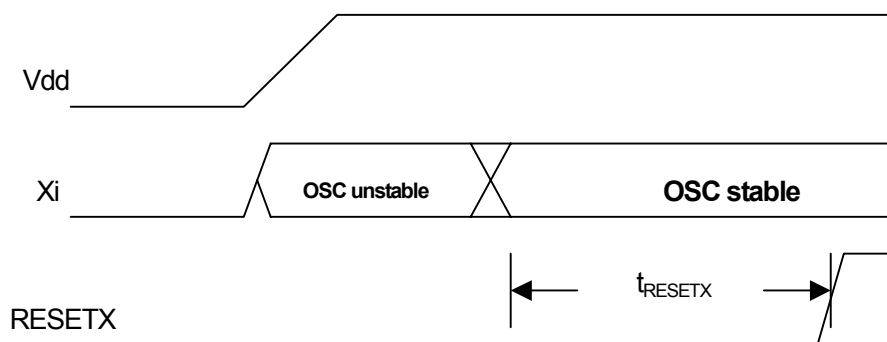


Fig. 1-3 Reset Timing

Table 1-4 Reset Time

Symbol	Time
t_{RESETX}	$\geq 1\mu s$

2 System Clock

Audio data samples must be transferred in synchronism between all components of the digital audio system. That is, for each audio sample originated by an audio source there must be one and only one audio sample processed by the NJU26106 and delivered to the D/A converters. To accomplish this, one device in the system is selected to generate the audio sample rate; the remaining devices are designated to follow this sample rate. The device that generates the audio sample rate is called the MASTER device; all devices following this sample rate are called SLAVE(s)

LR, BCK and MCK should be synchronized. This is described in next section 2.1. When the NJU26106 is in MASTER mode, the NJU26106 system clock should be 768 multiples of the sampling frequency (Table2-1). When the NJU26106 is in SLAVE mode, NJU26106 system clock should be from 768 multiples of the sampling frequency to the maximum operating frequency.

2.1 Audio Clock

Three types of clock signals are included in the serial audio interface. Two of the clock signals LR (LRI and LRO) and BCK (BCKI and BCKO) establish data transfer on the serial data lines. The third clock, MCK, is not associated with serial data transfer but is required by delta-sigma A/D and D/A converters.

The frequency of the LR clock is, by definition, equal to the digital audio sample rate, F_s . BCK and MCK operate at multiples of the LR clock rate. Therefore the signals LR, BCK and MCK must be locked, that is, they must be generated or derived from a single frequency reference. In SLAVE mode, the NJU26106 dose not generate MCK clock.

Table2-1 Sampling Frequency and BCK, MCK, Xi

Clock Signal	Multiple Frequency	32Khz	44.1kHz	48kHz
LR	1Fs	32kHz	44.1kHz	48kHz
BCK(32fs)	32Fs	1.024MHz	1.4112MHz	1.536MHz
BCK(64fs)	64Fs	2.048MHz	2.822MHz	3.072MHz
MCK(256fs)	256Fs	8.192MHz	11.289MHz	12.288MHz
MCK(384fs)	384Fs	12.288MHz	16.934MHz	18.432MHz
Xi	768Fs	24.576MHz	33.8688MHz	36.864MHz

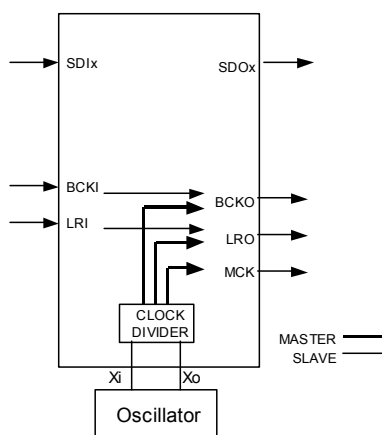


Fig. 2-1 MASTER / SLAVE Mode

3. Audio Interface

The serial audio interface carries audio data to and from the NJU26106. Industry standard serial data formats of I²S, MSB-first left-justified or MSB-first right-justified are supported. These serial audio formats define a pair of digital audio signals (stereo audio) on each data line. Two clock lines, BCK (bit clock) and LR (left/right word clock) establish timing for serial data transfers.

The NJU26106 serial audio interface includes two data input lines; SDI0 and SDI1 and three data output lines, SDO1, SDO2, SDO3 as shown in the figure below. The input serial data is selected by the firmware command.

Table 3-1 Serial Audio Output Pin Description

Symbol	Pin No.	Description
SDO0	3	Front Lch/Rch Output(*)
SDO1	2	Center/Sub Woofer Output
SDO2	1	Rear Lch/Rch Output

(*) In Virtual Dolby Surround mode, only front Lch/Rch output signal. The other channels are muted.

The NJU26106 has a pair of left/right clock lines (LRI and LRO) and a pair of bit clock lines (BCKI and BCKO). Clock inputs BCKI and LRI are used to accept timing signals from an external device when the NJU26106 is operating in SLAVE clock mode.

The BCKO,LRO and system clock output MCK, is provided for delta-sigma A/D and D/A converters when the NJU26106 operates in MASTER mode. In SLAVE mode, the output of BCKO and LRO are the buffered output of BCKI and LRI. The output of MCK is fixed to low level in SLAVE mode.

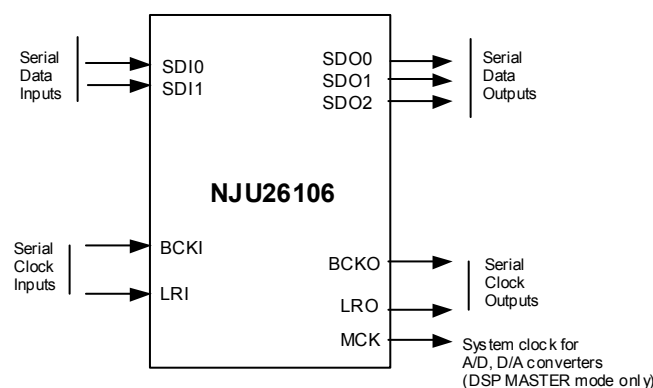


Fig. 3-1 Serial Audio Interface

3.1 Audio Data Format

The NJU26106 can exchange data using any of three industry-standard digital audio data formats: I²S, MSB-first Left-justified, or MSB-first Right-justified.

The three serial formats differ primarily in the placement of the audio data word relative to the LR clock. Left-justified format places the most-significant data bit (MSB) as the first bit after an LR transition. I²S format places the most-significant data bit (MSB) as the second bit after an LR transition (one bit delay relative to left-justified format). Right-justified format places the least-significant data bit (LSB) as the last bit before an LR transition.

Clock LR (LRI, LRO) marks data word boundaries and clock BCK (BCKI, BCKO) clocks the transfer of serial data bits. One period of LR defines a complete stereo audio sample and thus the rate of LR equals the audio sample rate (Fs). All formats transmit the stereo sample left channel first. Note that polarity of LR is opposite in I²S format (LR:LOW = Left channel data) compared to Left-Justified or Right-Justified formats.

The number of BCK clock must follow the serial data format. If the BCK clock is not enough, the right sound are not produced. Set serial data format for the adequate mode that A/Ds, D/As or Codecs require.

The NJU26106 supports serial data format which includes 32(32fs) or 64(64fs) BCK clocks. This serial data format is applied to both MASTER and SLAVE mode.

3.2 Serial Audio Data Transmitting Diagram

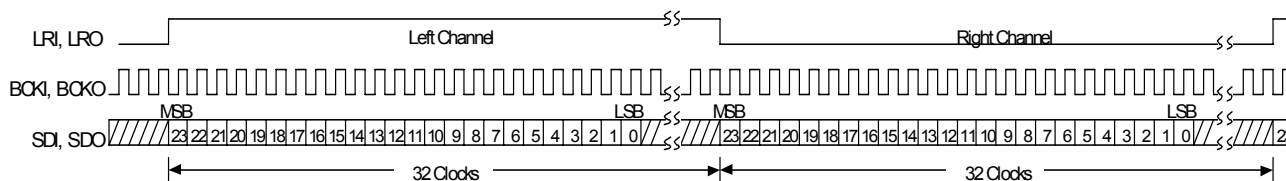


Fig. 3-2 Left-Justified Data Format 64Fs, 24bit Data

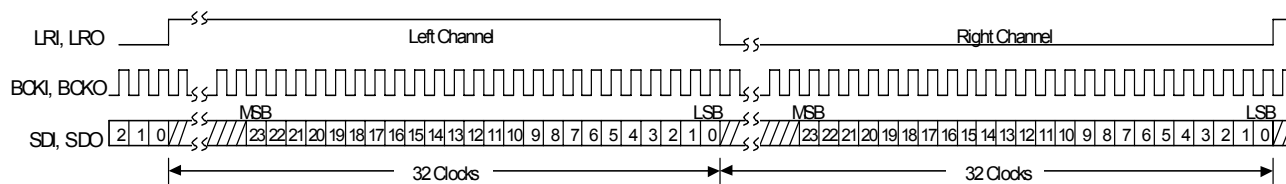


Fig. 3-3 Right-Justified Data Format 64Fs, 24bit Data

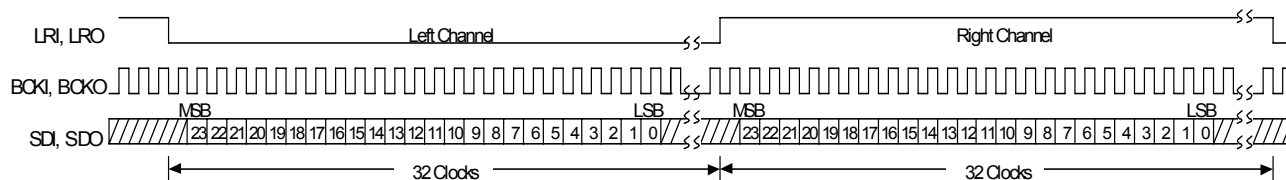


Fig. 3-4 I²S Data Format 64Fs, 24bit Data

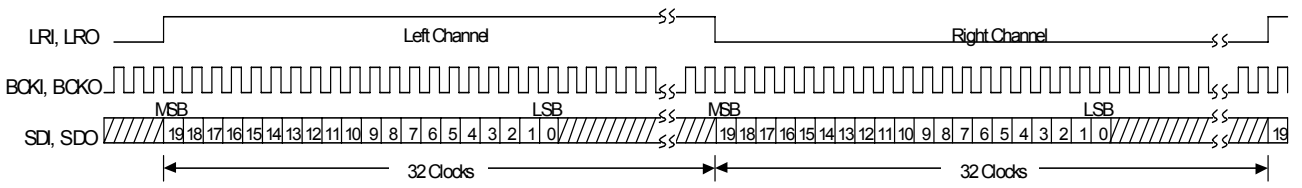


Fig. 3-5 Left-Justified Data Format 64Fs, 20bit Data

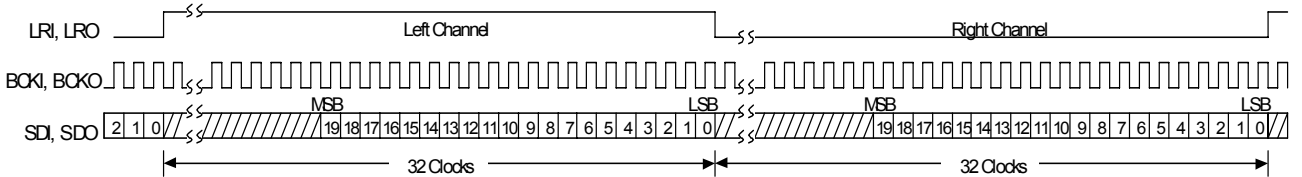


Fig. 3-6 Right-Justified Data Format 64Fs, 20bit Data

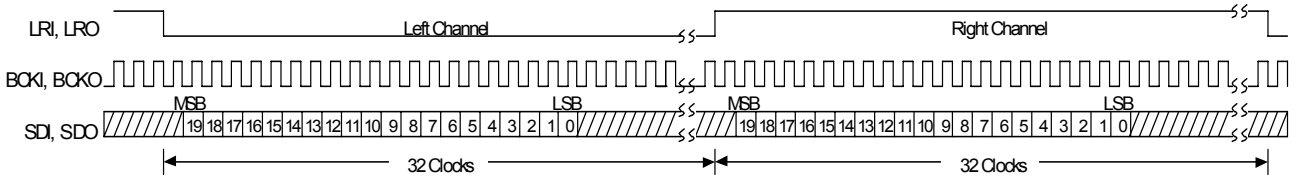


Fig. 3-7 I²S Data Format 64Fs, 20bit Data

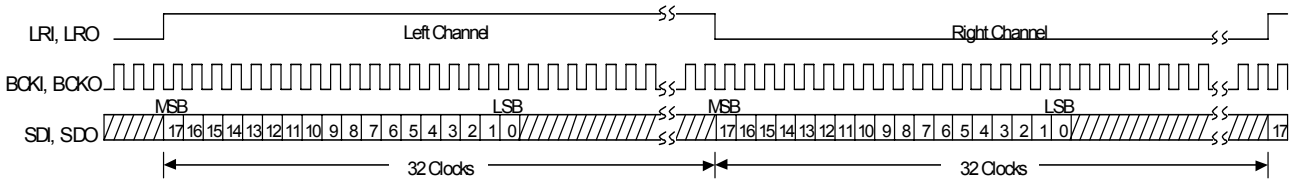


Fig. 3-8 Left-Justified Data Format 64Fs, 18bit Data

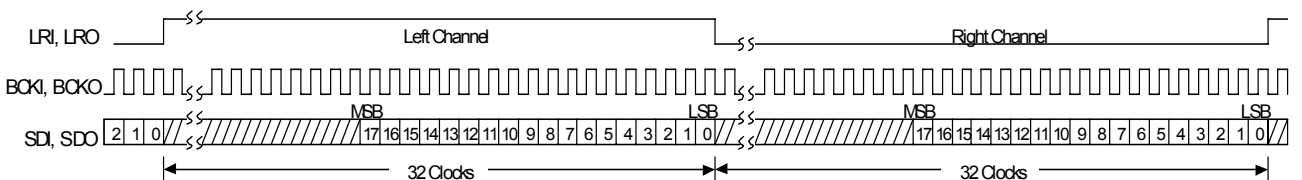


Fig. 3-9 Right-Justified Data Format 64Fs, 18bit Data

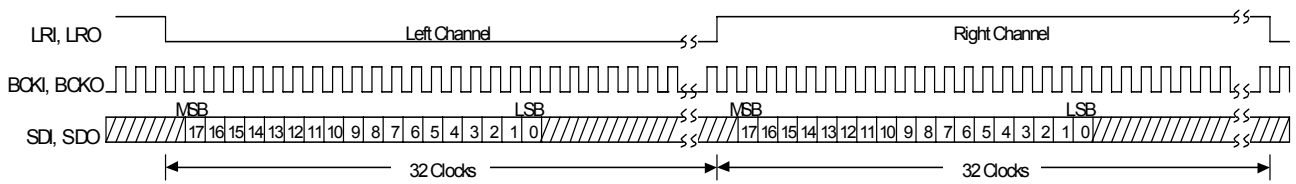


Fig. 3-10 I²S Data Format 64Fs, 18bit Data

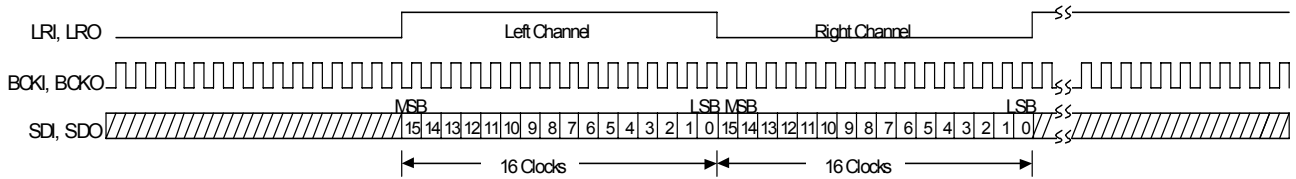


Fig. 3-11 Left-Justified Data Format 32Fs, 16bit Data

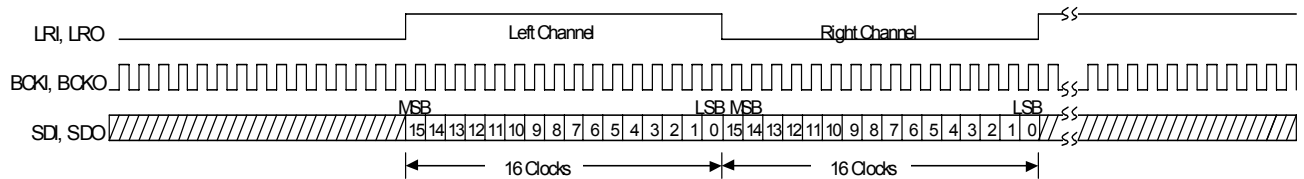


Fig. 3-12 Right-Justified Data Format 32Fs, 16bit Data

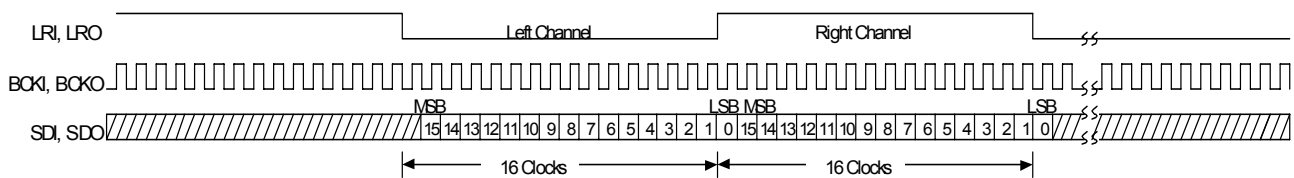


Fig. 3-13 I²S Data Format 32Fs, 16bit Data

3.3 Serial Audio Timing

Table 3-2 Serial Audio Input Timing Parameters

Parameter	Symbol	Test Condition	Min	Typ.	Max	Units
BCKI Frequency			0.9	-	4.0	MHz
BCKI Period						
L Pulse Width	t_{SIL}		85	-	-	ns
H Pulse Width	t_{SIH}		85	-	-	ns
BCKI to LRI Time	T_{SLI}		40	-	-	ns
LRI to BCKI Time	t_{LSI}		40	-	-	ns
Data Setup Time	t_{DS}		40	-	-	ns
Data Hold Time	t_{DH}		40	-	-	ns

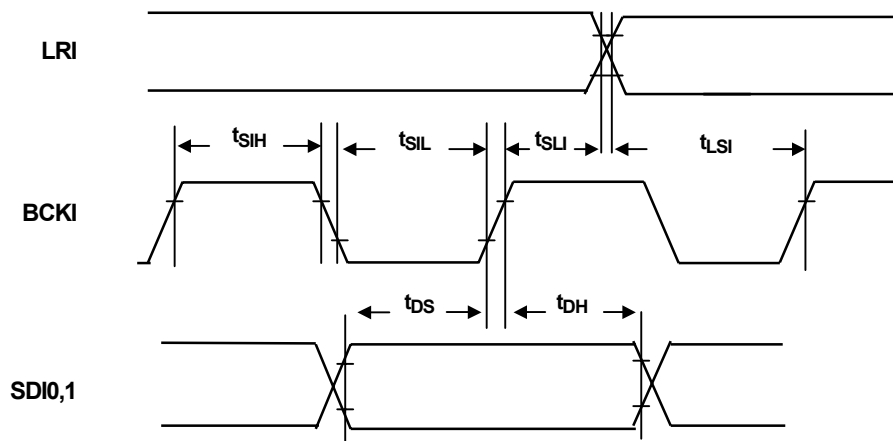


Fig. 3-14 Serial Audio Input Timing

Table 3-3 Serial Audio Output Timing Parameters

Parameter	Symbol	Test Condition	Min	Typ.	Max	Units
BCKO Period L Pulse Width H Pulse Width	t_{SOL} t_{SOH}	C_L :LRO, BCKO, SDO=25pF	t_{SIL-40} t_{SIH-40}	-	t_{SIL+40} t_{SIH+40}	ns
BCKO to LRO Time	t_{SLO}		20	-	-	ns
LRO to BCKO Time	t_{LSO}		20	-	-	ns
Data Output Delay	t_{DOD}		-	-	20	ns

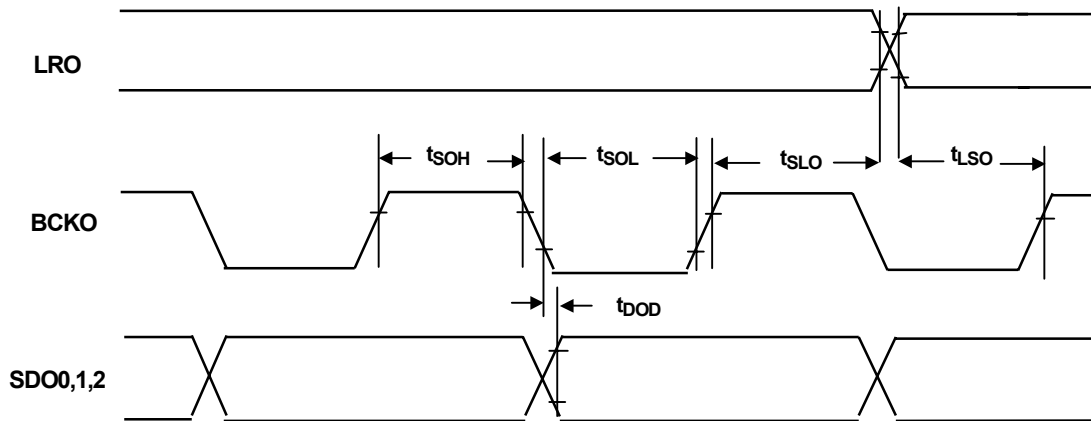


Fig. 3-15 Serial Audio Output Timing

4. Host Interface

The NJU26106 can be controlled via Serial Host Interface (SHI) using either of two serial bus format : 4-Wire serial bus or I²C bus. Data transfers are in 8 bit packets (1 byte) when using either format. The SHI operates only in a SLAVE fashion. A host controller connected to the interface always drives the clock (SCL / SCK) line and initiates data transfers, regardless of the chosen communication protocol.

The SEL1 pin controls the serial bus mode. When the SEL1 is low during the NJU26106 initialization, 4-Wire serial bus is available. When the SEL1 is high during the NJU26106 initialization, I²C bus is available.

Table 4-1 Serial Host Interface Pin Description

Symbol (I ² C / Serial)	Pin No.	4-Wire Serial bus Format	I ² C bus Format
SCL/SCK	5	Serial Clock	Serial Clock
SDA/SDOUT	6	Serial Data Output	Serial Data (Bi-directional)
AD1/SDIN	7	Serial Data Input	I ² C bus address Bit1
AD2/SSx	8	SLAVE Select	I ² C bus address Bit2

Note : SDA /SDOUT pin is a bi-directional open drain. When 4-Wire Serial bus is selected, and SSX is effective, and a CMOS output and SSX are invalid, it will be in a Hi-Z state. This pin, which is assigned for 4-Wire serial bus format or for I²C, requires a 4.7k pull-up resistor.

4.1 4-Wire Serial Interface

The serial host interface can be configured for 4-Wire Serial bus communication by setting SEL1="H" during the Reset Sequence initialization. SHI bus communication is full-duplex; a write byte is shifted into the SDIN pin at the same time that a read byte is shifted out of the SDOUT pin. Data transfers are MSB first and are enabled by setting the Slave Select pin LOW (SSX = 0). Data is clocked into SDIN on rising transitions of SCK. Data is latched at SDOUT on falling transitions of SCK except for the first byte (MSB) which is latched on the falling transitions of SSX. SDOUT is Hi-Z in case of SSX = "H". SDOUT is CMOS output in case of SSX = "L". SDOUT needs a pull-up resistor when SDOUT is Hi-Z.

Table 4-2 4-Wire Serial Interface Timing Parameters

Parameter	Symbol	Timelines	Min.	Typ.	Max.	Units
Input Data Rising Time	t_{MSDr}	a-b	-	-	100	ns
Input Data Falling Time	t_{MSDf}	a-b	-	-	100	ns
Serial Clock Rising Time	t_{MSCr}	d-e	-	-	100	ns
Serial Clock Falling Time	t_{MSCf}	f-g	-	-	100	ns
Serial Strobe Rising Time	t_{MSSr}	p-q	-	-	100	ns
Serial Strobe Falling Time	t_{MSSf}	m-n	-	-	100	ns
Serial Clock H Duration	t_{MSCa}	e-f	50	-	-	ns
Serial Clock L Duration	t_{MSCn}	g-h	50	-	-	ns
Serial Clock Period	t_{MSCc}	e-i	250	-	-	ns
Serial Strobe Setup Time	t_{MSSs}	n-e	100	-	-	ns
Serial Strobe Hold Time	t_{MSSH}	j-q	30	-	-	ns
Serial Strobe L Duration	t_{MSSa}	n-p	-	1.0	-	μ s
Serial Strobe H Duration	t_{MSSn}	q-r	40	-	-	ns
Input Data Setup Time	t_{MSDis}	b-e	20	-	-	ns
Input Data Hold Time	t_{MSDih}	e-c	20	-	-	ns
Output Data Delay (From SSx)	t_{MSDos}	n-o, CL=25pF	-	-	50	ns
Output Data Delay (From SCLK)	t_{MSDo}	g-k(data-6), CL=25pF	-	-	50	ns
Output Data Hold Time	t_{MSDoh}	g-k(data-7)	0	-	-	ns
Output Data Turn off Time (Hi-Z)	t_{MSDov}	q-l	-	-	40	ns

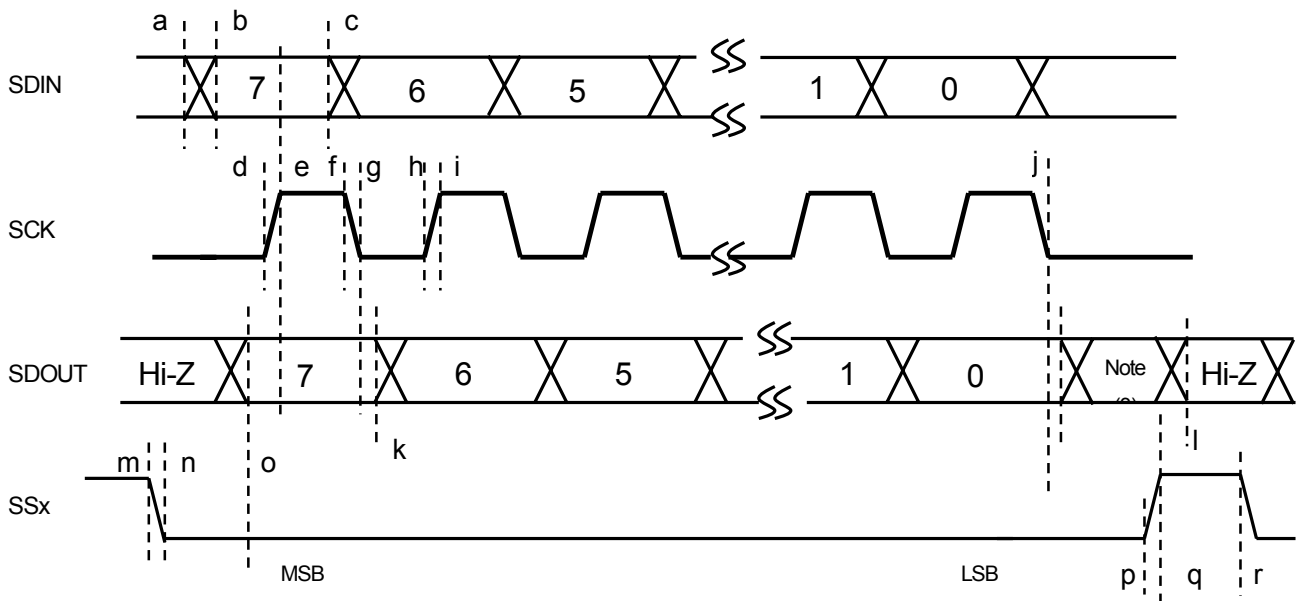


Fig. 4-1 4-Wire Serial Interface Timing

- Note :
- *1 When the data-clock is less than 8 clocks, the input data is shifted to LSB side and is sent to the DSP core at the transition of SSX="H".
 - *2 When the data-clock is more than 8 clocks, the last 8 bit data becomes valid.
 - *3 After sending LSB data, SDOUT transmits the MSB data which is received via SDIN until SSX becomes "H".
 - *4 SDOUT is Hi-Z in case of SSX = "H". SDOUT is CMOS output in case of SSX = "L". SDOUT needs a pull-up resistor to prevent SDOUT from becoming floating level.

4.2 I²C Bus

When the NJU26106 is configured for I²C bus communication in SEL1="L", the serial host interface transfers data on the SDA pin and clocks data on the SCL pin. SDA is an open drain pin requiring an external 4.7k pull-up resistor. Pins AD1 and AD2 are used to configure the seven-bit SLAVE address of the serial host interface. This offers additional flexibility in a system design by offering two different possible SLAVE addresses for which the NJU26106 will respond to. An address can be arbitrarily set up with an internal setup and this AD1 terminal. In the NJU26106, AD2 pin should be connected to "H". Any I²C address could be chosen for AD1. The I²C address of AD1 is decided by connection of AD1-pin. The I²C address should be the same level of AD1-pin

Table 4-3 I²C Bus SLAVE Address

bit7	bit6	bit5	bit4	Bit3	bit2	bit1	bit0
0	0	1	1	1	AD2* ¹	AD1* ²	R/W

*1 AD2 pin should be connected to high. The I²C address of AD2 should be 1.

*2 SLAVE address is 0 when AD1 is L. SLAVE address is 1 when AD1 is H.

The figure on the following page shows the basic timing relationships for transfers. A transfer is initiated with a START condition, followed by the SLAVE address byte. The SLAVE address consists of the seven-bit SLAVE address followed by a read/write (R/W) bit. When an address with an effective serial host interface is detected, the acknowledgement bit which sets a SDA line to LOW in the ninth bit clock cycle is returned.

The R/W bit in the SLAVE address byte sets the direction of data transmission until a STOP condition terminates the transfer. R/W = 0 indicates the host will send to the NJU26106 while R/W = 1 indicates the host will receive data from the NJU26106.

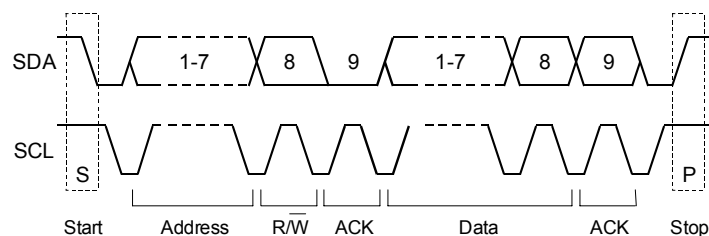


Fig. 4-2 I²C Bus Format

In case of the NJU26106, only single-byte transmission is available.

The serial host interface supports "Standard-Mode (100kbps)" I²C bus data transfer.

Table 4-4 I²C Bus Interface Timing Parameters

Parameter	Symbol	Standard Mode		Units
		Min	Max	
SCL Clock Frequency	f_{SCL}	0	100	kHz
Start Condition Hold Time	$t_{HD:STA}$	4.0	-	μ s
SCL "L" Duration	t_{LOW}	4.7	-	μ s
SCL "H" Duration	t_{HIGH}	4.0	-	μ s
Start Condition Setup Time	$t_{SU:STA}$	4.7	-	μ s
Data Hole Time	$t_{HD:DAT}$	0	3.45	μ s
Data Setup Time	$t_{SU:DAT}$	250	-	ns
Rising Time	t_R	-	1000	ns
Falling Time	t_F	-	300	ns
Stop Condition Setup Time	$t_{SU:STO}$	4.0	-	μ s
Bus Release Time	t_{BUF}	4.7	-	μ s

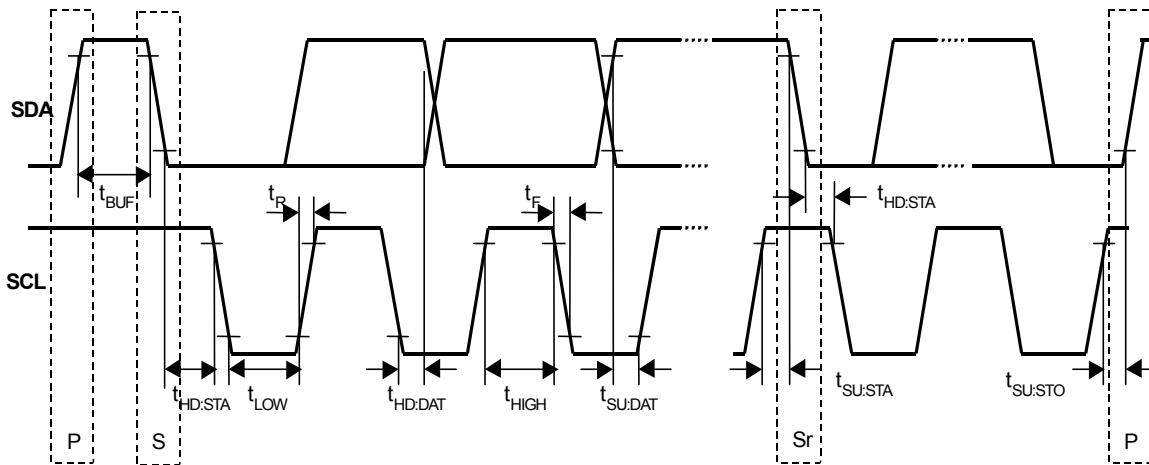


Fig. 4-3 I²C Bus Timing

5. Firmware Command Table

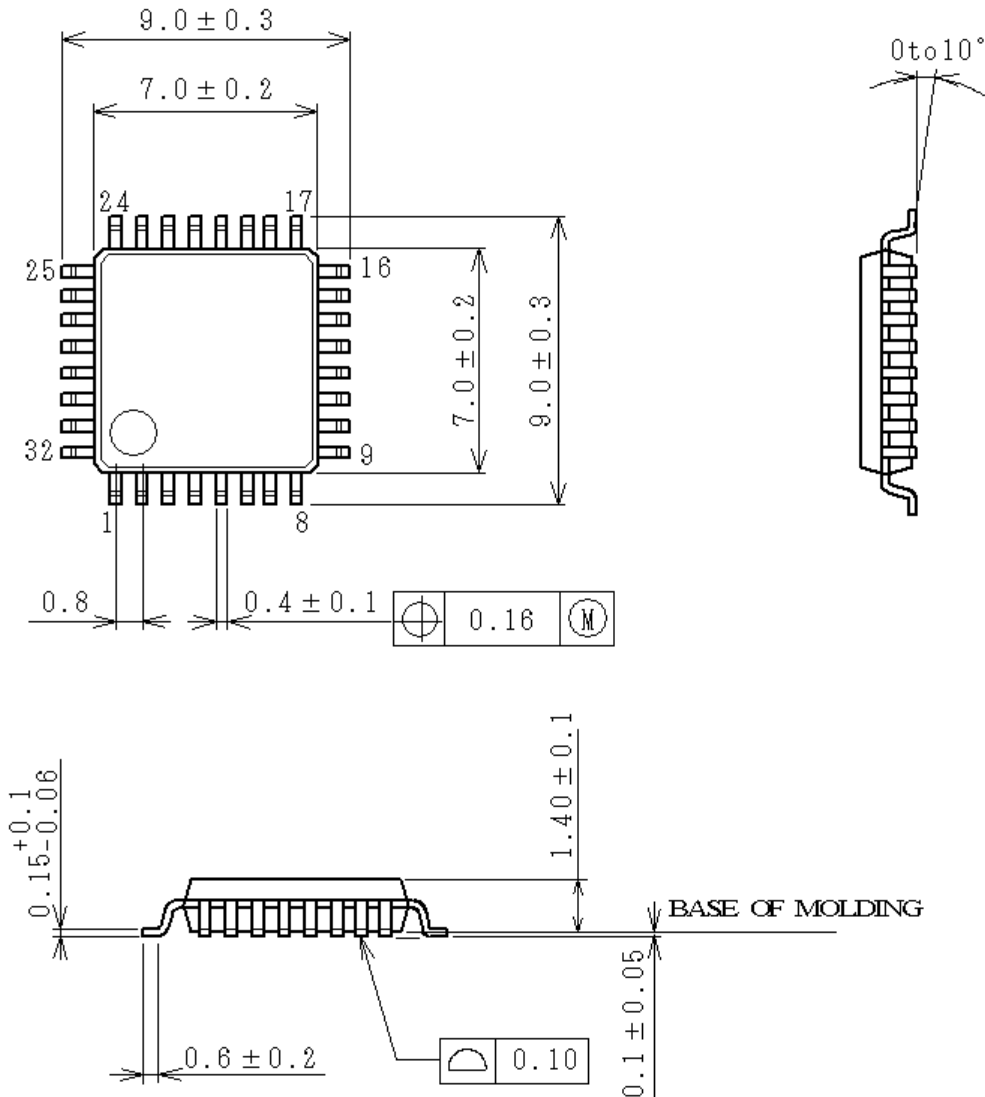
The NJU26106 allows for user configuration of the decoder with micro controller commands entered via Host interface (I²C bus or serial interface). The following table summarizes the available user commands.

Table5-1 NJU26106 Command

No.	Command System	Command Description
1	SET_TASK_CMD	Set decoding mode: Pro Logic II, Virtual Dolby Surround, Pink Noise Generator
2	VDS_ANG_CMD	Set Virtual Dolby Surround Speaker separation angle
3	DPL_SUR_CMD	Set Pro Logic II Decode Mode (Movie,Music,etc) and Panorama mode
4	CWIDTH_DIM_CMD	Set Pro Logic II Center Width and Dimension configuration
5	DPL_MOD_CMD	Set Pro Logic II Variable Setting, Auto input Balance and Shelf Filter, Rs Polarity Inversion, etc
6	BASS_MGNT_CMD	Set Bass Management Configuration, LFE Cutoff Frequency Configuration
7	FS_CMD	Set sampling rate
8	NOISE_CMD	Set Output Speaker Configuration for Pink Noise Generator
9	DLY_CMD	Set Surround Channel Delay Time
10	LR_BAL_CMD	Set L/R Volume Balance
11	MST_VOL_CMD	Set MASTER Volume
12	LCH_VOL_CMD	Set L Channel Volume
13	RCH_VOL_CMD	Set R Channel Volume
14	CENT_VOL_CMD	Set Center Channel Volume
15	SURR_LEFT_VOL_CMD	Set Surround Left Channel Volume
16	SURR_RIGHT_VOL_CMD	Set Surround Right Channel Volume
17	SW_VOL_CMD	Set Subwoofer Channel Volume
18	SYS_SET_CMD	Configure serial audio interface format, LR & BCK MASTER/SLAVE, etc.

NJU26106

■ Package Dimensions (EIAJ : QFP032-P-0707-1)



UNIT : mm

LEADS MATERIAL : 42ALLOY
 LEADS FINISH : SOLDER PLATING
 MOLD MATERIAL : EPOXY RESIN

Ver. 2.1

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