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AK7738

Multi DSP with 5ch ADC + 4ch DAC + 8ch SRC

1. General Description

The AK7738 is a highly integrated digital signal processor, including a 24-bit stereo ADC with MIC gain amplifiers, a 24-bit stereo ADC with input selector, a monaural ADC, two 32-bit stereo DACs, 4 stereo sampling rate convertors supporting the sampling frequency up to 192kHz, two DSPs and a Sub DSP for Audio/HF process. Each two DSPs and a Sub DSP has 2560step/fs (when fs=48kHz) parallel processing power. The AK7738 is capable of processing sound and voice such as for hands-free function simultaneously because two DSPs are able to work on different but synchronized sampling frequencies. As the AK7738 is a RAM based DSP, it is freely programmable for user requirements, such as acoustic effects and proprietary high performance hands-free function. The AK7738 is available in a 64-pin LQFP package.

2. Features

□ DSP1/DSP2: (Memory areas are shared by DSP1 and DSP2)

- **Word length: 28-bit (Simple floating point supported)**
- **Instruction cycle: 8.1ns (2560fs at fs=48kHz)**
- **Multiplier: 24 x 24 → 48-bit (Double precision arithmetic available)**
- **Divider: 24 / 24 → 24-bit (Floating point normalization function)**
- **ALU: 52-bit arithmetic operation (with 4bits overflow margin)**
- **Program RAM: 8192 word x 36-bit**
- **Coefficient RAM: 6144 word x 24-bit**
- **Data RAM: 6144 word x 28-bit**
- **Delay RAM: 20480 word x 28-bit**
- **JX pins (Interrupt)**
- **Clock Mode Selector for DSP1, DSP2**
- **Independent Power Management Function for DSP1, DSP2**

□ Sub DSP

- **Word length: 28-bit (Simple floating point supported)**
- **Instruction cycle: 8.1ns (2560fs at fs=48kHz)**
- **Multiplier: 24 x 24 → 48-bit (Double precision arithmetic available)**
- **Divider: 24 / 24 → 24-bit (Floating point normalization function)**
- **ALU: 52-bit arithmetic operation (with 4bits overflow margin)**
- **Program RAM: 1024 word x 36-bit**
- **Coefficient RAM: 2048 word x 24-bit**
- **Data RAM: 4096 word x 28-bit**

□ ADC1: 24-bit Stereo ADC with MIC Gain Amplifiers

- **Sampling Frequency: fs=8kHz to 192kHz**
- **Channel Independent Analog Gain Amplifiers**
  (0 to 18dB(2dB Step), 18 to 36dB(3dB step))
- **Differential Input or Single-ended Input**
- **ADC Characteristics S/N: 102dB (fs=48kHz, Differential Input, MIC Gain=0dB,)**
- **Channel Independent Digital Volume Control (+24 to -103dB, 0.5dB Step, Mute)**
- **Analog DRC (Dynamic Range Control)**
- **Digital HPF for DC Offset Cancelling**
- **Low Noise MIC Power Output: 2ch**
- **4 types of Digital Filter for Sound Color Selection**

□ ADC2: 24-bit Stereo ADC with Input Selector
- **Sampling Frequency: fs=8kHz to 192kHz**
- **Analog Input Selector: Differential Input x1 or Single-ended Input x2, Semi-Differential Input x1**
- **ADC Characteristics S/N: 102dB (fs=48kHz, Differential Input)**
- **Channel Independent Digital Volume (+24 to -103dB, 0.5dB Step, Mute)**
- **Digital HPF for DC Offset Cancelling**
- **4 types of Digital Filter for Sound Color Selection**

□ ADCM: 24-bit Monaural ADC
- **Sampling Frequency: fs=8kHz to 192kHz**
- **Differential Input or Single-ended Input**
- **ADC Characteristics S/N: 102dB (fs=48kHz, Differential Input)**
- **Channel Independent Digital Volume (+24 to -103dB, 0.5dB Step, Mute)**
- **Digital HPF for DC Offset Cancelling**
- **4 types of Digital Filter for Sound Color Selection**

□ DAC: Advanced 32-bit DAC
- **2ch x2**
- **Sampling Frequency: fs=8kHz to 192kHz**
- **Single-ended Output**
- **DAC Characteristics S/N: 108dB (fs=48kHz)**
- **Channel Independent Digital Volume Control (+12 to -115dB, 0.5dB Step, Mute)**
- **4 types of Digital Filter for Sound Color Selection**

□ SRC:
- **2ch x4**
- **FSI = 8kHz to 192kHz, FSO = 8kHz to 192kHz (FSO/FSI = 0.167 to 6.0)**

□ FSCONV: Monaural Simple SRC
- **1ch x2**
- **FSI = 44.1kHz to 48kHz, FSO = 8kHz to 16kHz (FSO/FSI = 0.167 to 0.363)**

□ DIT:
- **S/PDIF, IEC60958, AES/EBU, EIAJ CP1201 Compatible**
- **24-bit Stereo Output**

□ Digital Interface:
- **Digital Input Port: max 24ch when TDM mode**
- **Digital Output Port: max 28ch when TDM mode**
- **Independent LRCK/BICK Input port x 5 Lines**
- **Data Format: MSB 32,24-bit / LSB 24,20,16-bit / I^2S**
- **PCM Short / Long Frame Supported**
- **TDM Format Supported**

□ Digital Mixer Circuit

□ PLL Circuit

□ µP Interface: SPI(7MHz max), I^2C-bus (1MHz, Fast Mode Plus)

□ Power Supply:
- **Analog AVDD: 3.0 to 3.6V (typ. 3.3V)**
- **Digital LVDD: 3.0 to 3.6V (typ. 3.3V) (3.3V → 1.2V regulator integrated)**
- **I/F VDD33: 3.0 to 3.6V (typ. 3.3V)**
  TVDD1: 1.7 to 3.6V (typ. 3.3V)
  TVDD2: 1.7 to 3.6V (typ. 3.3V)

□ Operating Temperature Range: -40°C to 85°C

□ Package: 64-pin LQFP (10mm x 10mm, 0.5mm pitch)

3. Table of Contents

4. Block Diagram and Functions

■ Block Diagram

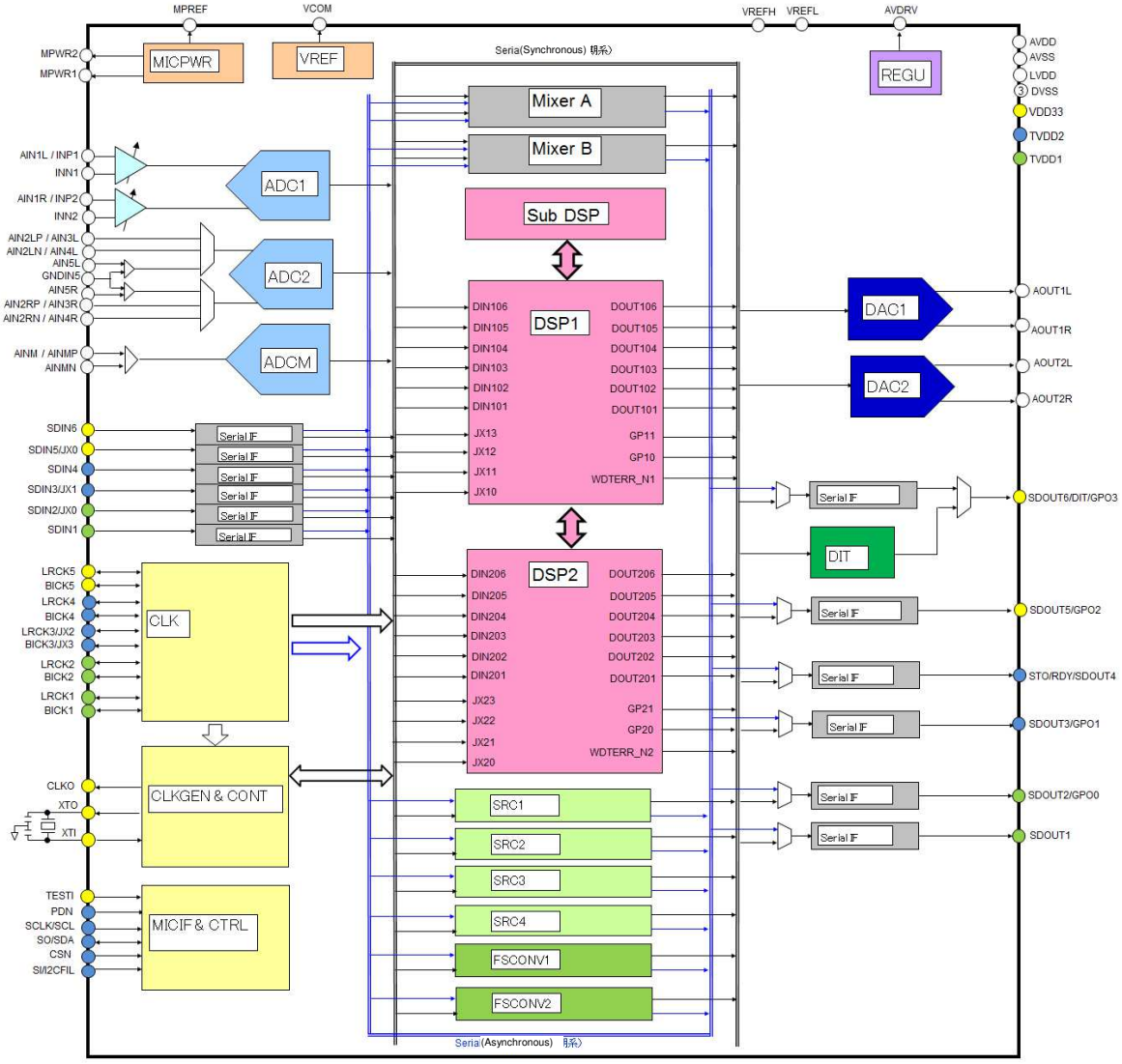


Figure 1. Block Diagram

■ DSP1 Block Diagram

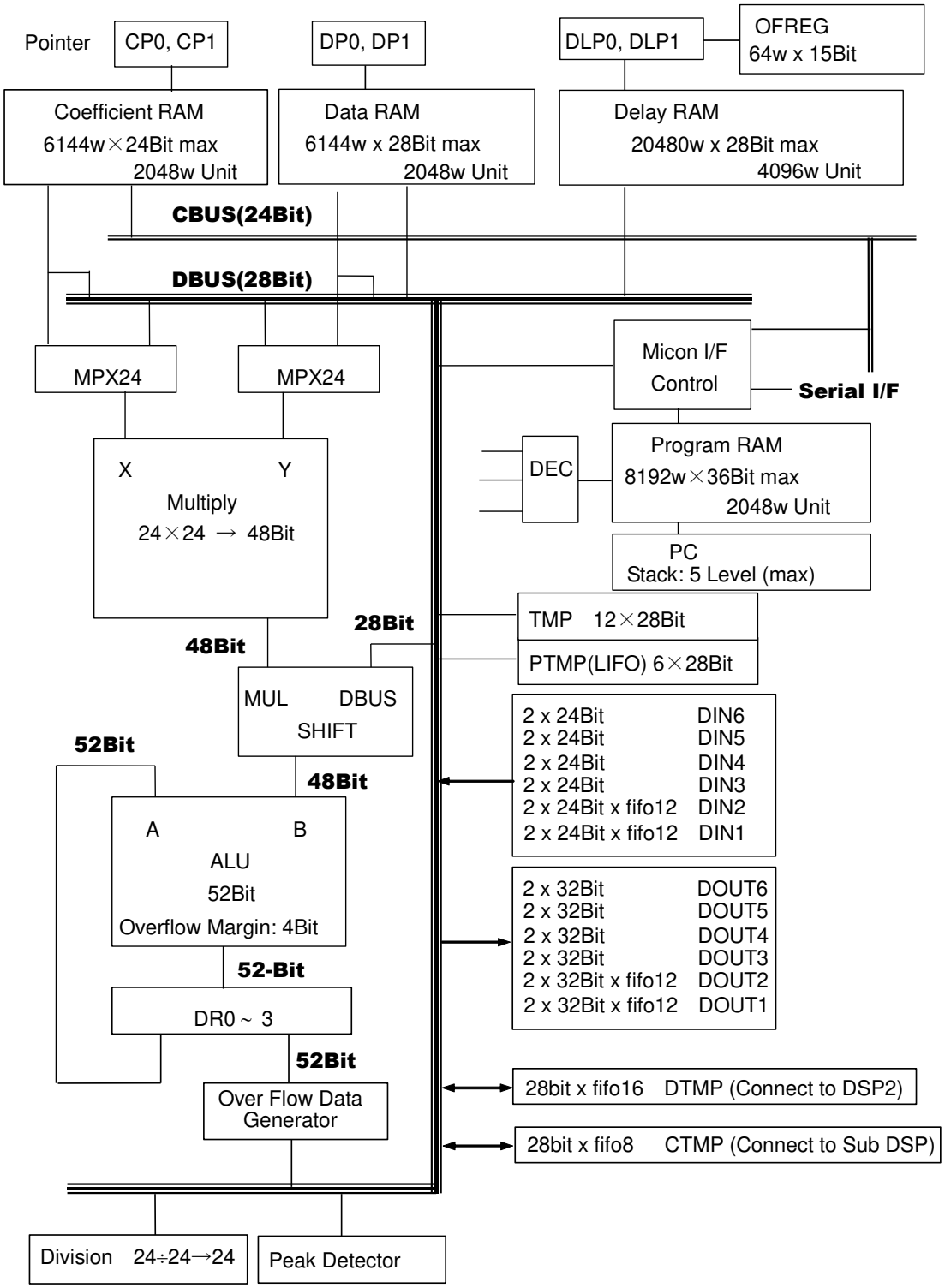


Figure 2. DSP1 Block Diagram (Note 1)

Note 1. Coefficient RAM, Data RAM, Delay RAM, Program RAM areas are shared by DSP1 and DSP2 and the sizes are configurable by control registers.

■ DSP2 Block Diagram

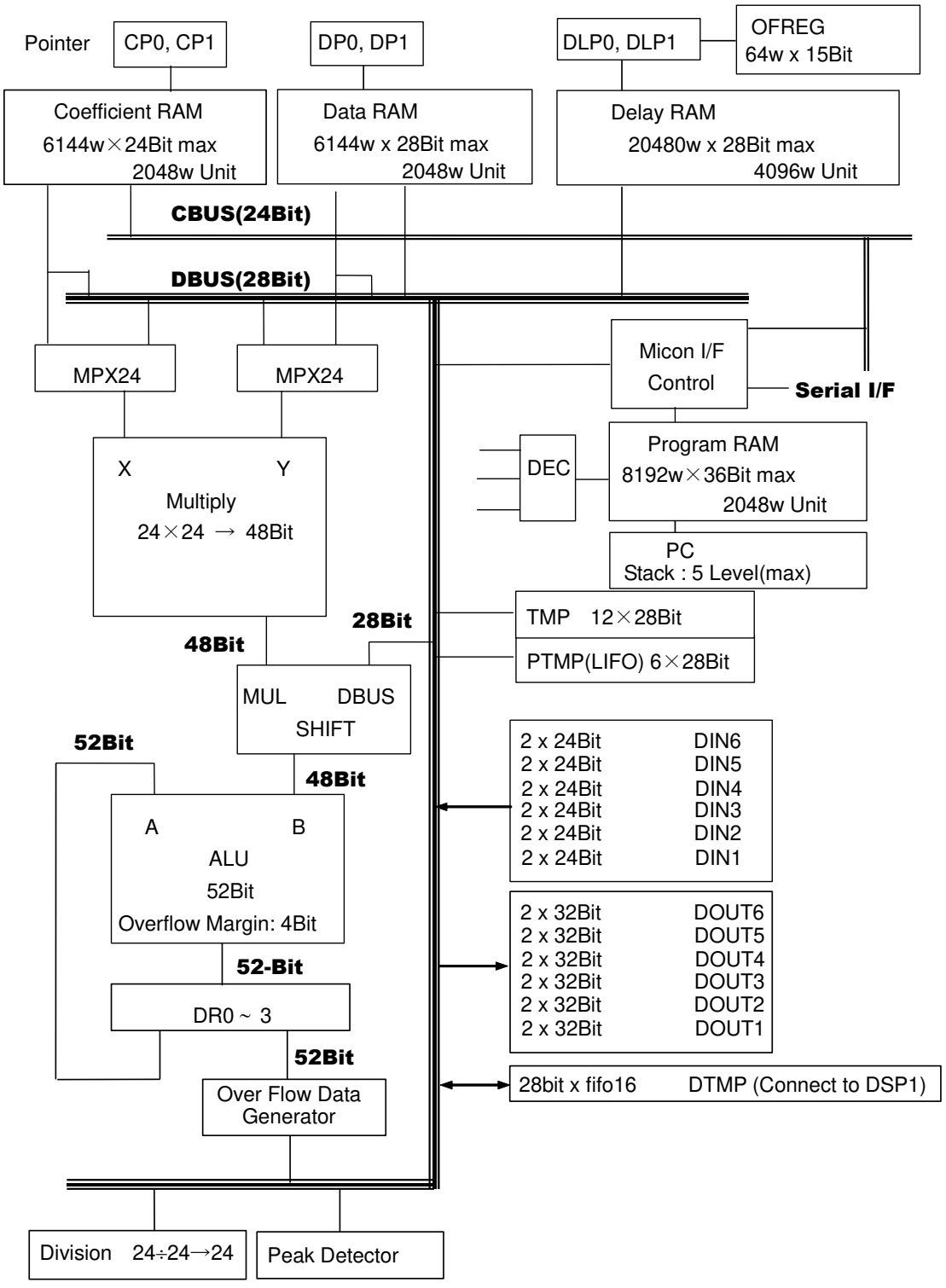


Figure 3. DSP2 Block Diagram (Note 1)

■ Sub DSP Block Diagram

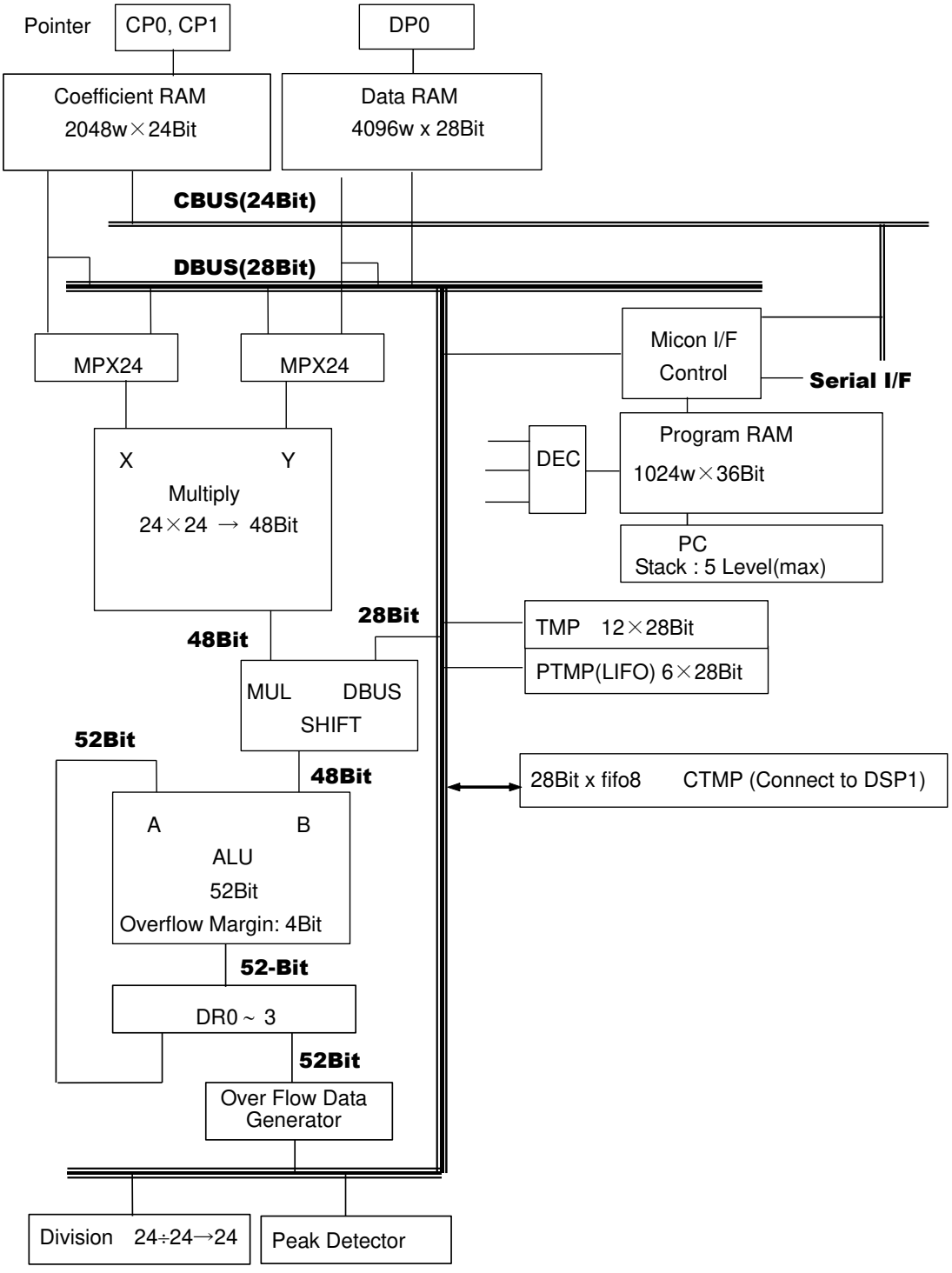


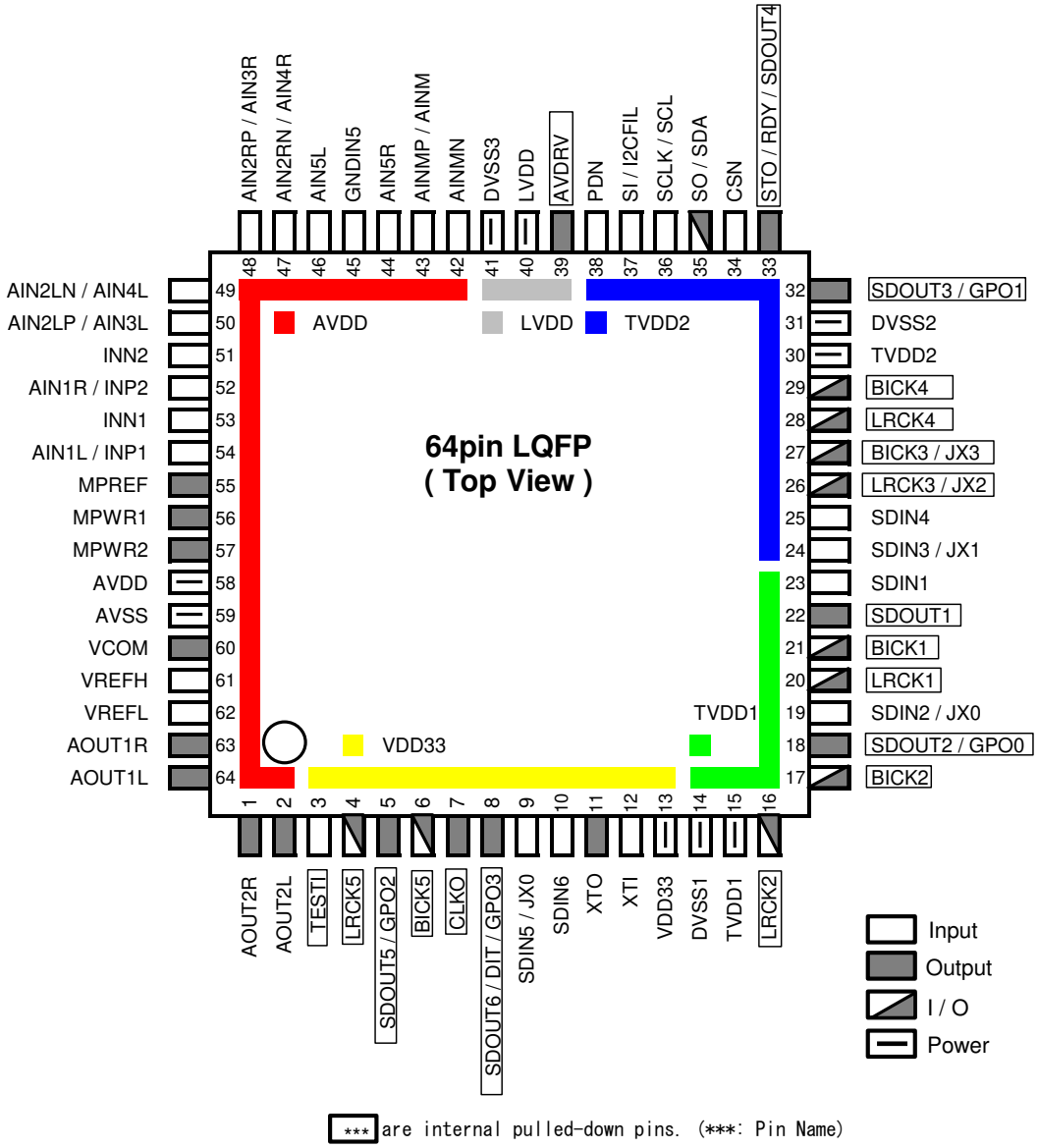
Figure 4. Sub DSP Block Diagram

5. Pin Configurations and Functions

■ Ordering Guide

AK7738VQ:	-40 ~ +85°C	64-pin LQFP (0.5mm pitch)
AKD7738:	Evaluation Board for AK7738	

■ Pin Layout



■ Pin Functions

No.	Pin Name	I/O	Function
1	AOUT2R	O	DAC2 Rch Analog Output Pin This pin outputs "Hi-Z" during power-down state.
2	AOUT2L	O	DAC2 Lch Analog Output Pin This pin outputs "Hi-Z" during power-down state.
3	TESTI	I	Test Input Pin It must be tied "L".
4	LRCK5	I/O	LR Channel Select Clock 5 Pin
5	SDOUT5	O	Serial Data Output 5 Pin
	GPO2	O	DSP Programmable Output 2 Pin (GPO0 Output of DSP2)
6	BICK5	I/O	Serial Bit Clock 5 Pin
7	CLKO	O	Master Clock Output Pin
8	SDOUT6	O	Serial Data Output 6 Pin
	DIT	O	Digital Transmit Channel Output Pin
	GPO3	O	DSP Programmable Output 3 Pin (GPO1 Output of DSP2)
9	SDIN5	I	Serial Data Input 5 Pin
	JX0	I	External Conditional Jump Input 0 Pin
10	SDIN6	I	Serial Data Input 6 Pin
11	XTO	O	Crystal Oscillator Output Pin When using a crystal oscillator, connect it between XTI and XTO. When not using a crystal oscillator, leave this pin open.
12	XTI	I	Crystal Oscillator Input Pin When using a crystal oscillator, connect it between XTI and XTO. When not using a crystal oscillator, connect this pin to an external clock or DVSS1.
13	VDD33	-	Digital I/F Power Supply Pin 3.0~3.6V (typ.3.3V)
14	DVSS1	-	Digital Ground 1 Pin 0V (Substrate potential)
15	TVDD1	-	Digital I/F Power Supply 1 Pin 1.7~3.6V (typ.3.3V)
16	LRCK2	I/O	LR Channel Select Clock 2 Pin
17	BICK2	I/O	Serial Bit Clock 2 Pin
18	SDOUT2	O	Serial Data Output 2 Pin
	GPO0	O	DSP Programmable Output 0 Pin (GPO0 Output of DSP1)
19	SDIN2	I	Serial Data Input 2 Pin
	JX0	I	External Conditional Jump Input 0 Pin
20	LRCK1	I/O	LR Channel Select Clock 1 Pin
21	BICK1	I/O	Serial Bit Clock 1 Pin
22	SDOUT1	O	Serial Data Output 1 Pin
23	SDIN1	I	Serial Data Input 1 Pin

No.	Pin Name	I/O	Function
24	SDIN3	I	Serial Data Input 3 Pin
	JX1	I	External Conditional Jump Input 1 Pin
25	SDIN4	I	Serial Data Input 4 Pin
26	LRCK3	I/O	LR Channel Select Clock 3 Pin
	JX2	I	External Conditional Jump Input 2 Pin
27	BICK3	I/O	Serial Bit Clock 3 Pin
	JX3	I	External Conditional Jump Input 3 Pin
28	LRCK4	I/O	LR Channel Select Clock 4 Pin
29	BICK4	I/O	Serial Bit Clock 4 Pin
30	TVDD2	-	Digital I/F Power Supply 2 Pin 1.7~3.6V (typ.3.3V)
31	DVSS2	-	Digital Ground 2 Pin 0V (Substrate potential)
32	SDOUT3	O	Serial Data Output 3 Pin
	GPO1	O	DSP Programmable Output 1 Pin (GPO1 Output of DSP1)
33	STO	O	Status Output Pin This pin outputs "L" during power-down state.
	RDY	O	RDY Signal Output Pin
	SDOUT4	O	Serial Data Output 4 Pin
34	CSN	I	SPI Mode SPI I/F Chip Select N Pin During power-down state or when μP I/F are not in use, leave this pin "H" level.
		I	I^2C Mode I^2C I/F Chip Address N Pin This pin must be pulled up or pulled down.
35	SO	O	Serial Data Output Pin for SPI I/F This pin outputs "Hi-Z" during power-down state.
	SDA	I/O	Serial Data In/Output Pin for I^2C I/F This pin outputs "Hi-Z" during power-down state.
36	SCLK	I	Serial Data Clock Input Pin for SPI I/F
	SCL	I	Serial Data Clock Input Pin for I^2C I/F
37	SI	I	Serial Data Input Pin for SPI I/F
	I2CFIL	I	I^2C I/F Mode Select Input Pin I2CFIL = "L": Fast Mode (400kHz) I2CFIL = "H": Fast Mode Plus (1MHz) (should be fixed to TVDD2)
38	PDN	I	Power-down N Pin Use this pin to power down the AK7738. The PDN pin should be held "L" when power is supplied.
39	AVDRV	O	LDO Output Pin Connect a 2.2uF ceramic capacitor between this pin and DVSS3. Do not connect this pin to an external circuit.
40	LVDD	-	Digital Core Power Supply Pin 3.0~3.6V (typ.3.3V)
41	DVSS3	-	Digital Ground 3 Pin 0V (Substrate potential)

No.	Pin Name	I/O	Function
42	AINMN	I	ADCM Inverted Differential Input Pin
43	AINMP	I	ADCM Non-inverted Differential Input Pin
	AINM	I	ADCM Single-ended Input Pin
44	AIN5R	I	ADC2 Rch Pseudo Differential Input 5 Pin
45	GNDIN5	I	ADC2 Pseudo Differential Ground Input 5 Pin
46	AIN5L	I	ADC2 Lch Pseudo Differential Input 5 Pin
47	AIN2RN	I	ADC2 Rch Inverted Differential Input 2 Pin
	AIN4R	I	ADC2 Rch Single-ended Input 4 Pin
48	AIN2RP	I	ADC2 Rch Non-inverted Differential Input 2 Pin
	AIN3R	I	ADC2 Rch Single-ended Input 3 Pin
49	AIN2LN	I	ADC2 Lch Inverted Differential Input 2 Pin
	AIN4L	I	ADC2 Lch Single-ended Input 4 Pin
50	AIN2LP	I	ADC2 Lch Non-inverted Differential Input 2 Pin
	AIN3L	I	ADC2 Lch Single-ended Input 3 Pin
51	INN2	I	ADC1 Rch Inverted Differential Input 2 Pin
52	AIN1R	I	ADC1 Rch Single-ended Input 1 Pin
	INP2	I	ADC1 Rch Non-inverted Differential Input 2 Pin
53	INN1	I	ADC1 Lch Inverted Differential Input 1 Pin
54	AIN1L	I	ADC1 Lch Single-ended Input 1 Pin
	INP1	I	ADC1 Lch Non-inverted Differential Input 1 Pin
55	MPREF	O	Ripple Filter Pin for Microphone Power Supply Connect a 1uF ceramic capacitor between this pin and AVSS. Do not connect this pin to an external circuit.
56	MPWR1	O	Power Supply Output 1 Pin for Microphone This pin outputs “Hi-Z” during power-down state.
57	MPWR2	O	Power Supply Output 2 Pin for Microphone This pin outputs “Hi-Z” during power-down state.
58	AVDD	-	Analog Power Supply Pin 3.0~3.6V (typ.3.3V)
59	AVSS	-	Analog Ground Pin 0V (Substrate potential)
60	VCOM	O	Analog Common Voltage Output Pin Connect a 2.2uF ceramic capacitor between this pin and AVSS. Do not connect this pin to an external circuit. This pin outputs “L” during power-down state.
61	VREFH	I	Analog High-level Reference Voltage Input Pin Connect this pin to AVDD.
62	VREFL	I	Analog Low-level Reference Voltage Input Pin Connect this pin to AVSS.
63	AOUT1R	O	DAC1 Rch Analog Output Pin This pin outputs “Hi-Z” during power-down state.
64	AOUT1L	O	DAC1 Lch Analog Output Pin This pin outputs “Hi-Z” during power-down state.

■ Handling of Unused Pins

Unused I/O pins must be connected appropriately.

Classification	Pin Name	Setting
Analog	MPREF, MPWR1, MPWR2, AIN1L/INP1, INN1, AIN1R/INP2, INN2, AIN2LP/AIN3L, AIN2LN/AIN4L, AIN2RP/AIN3R, AIN2RN/AIN4R, AIN5L, GNDIN5, AIN5R, AINMP/AINM, AINMN, AOUT1L, AOUT1R, AOUT2L, AOUT2R	Open
Digital	CLKO, XTO, SDOUT1, SDOUT2/GPO0, SDOUT3/GPO1, STO/RDY/SDOUT4, SDOUT5/GPO2, SDOUT6/DIT/GPO3	Open
	XTI , SDIN6, SDIN5/JX0, SDIN4, SDIN3/JX1, SDIN2/JX0, SDIN1, LRCK1, BICK1, LRCK2, BICK2, LRCK3/JX2, BICK3/JX3, LRCK4, BICK4, LRCK5, BICK5, TESTI	Connect to DVSS1 ~ 3

Table 1. Handling of Unused Pins

Note 2. Although it is recommended that the LRCK1, BICK1, LRCK2, BICK2, LRCK3/JX2, BICK3/JX3, LRCK4, BICK4, LRCK5 and BICK5 pins are connected to DVSS1-3 when not using, they can be open since they are pulled down internally.

■ Internal Pulled-down Pin Status

Internal pulled-down I/O pins have different statuses in power-down and power-down release statuses.

No	Pin Name	I/O	Power Down Status PDN pin = "L"	Power Down Release PDN pin = "H" (when I/O pin = Input)	Power Down Release PDN pin = "H" (when I/O pin = Output)
3	TESTI	I	Pulled-down (25kΩ)	Pulled-down (25kΩ)	Pulled-down (25kΩ)
4	LRCK5	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
5	SDOUT5/GPO2	O	Pulled-down (50kΩ)	Output	Output
6	BICK5	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
7	CLKO	O	Pulled-down (50kΩ)	Output	Output
8	SDOUT6/DIT/GPO3	O	Pulled-down (50kΩ)	Output	Output
16	LRCK2	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
17	BICK2	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
18	SDOUT2/GPO0	O	Pulled-down (50kΩ)	Output	Output
20	LRCK1	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
21	BICK1	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
22	SDOUT1	O	Pulled-down (50kΩ)	Output	Output
26	LRCK3/JX2	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
27	BICK3/JX3	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
28	LRCK4	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
29	BICK4	I/O	Pulled-down (50kΩ)	Pulled-down (46kΩ)	Output
32	SDOUT3/GPO1	O	Pulled-down (50kΩ)	Output	Output
33	STO/RDY/SDOUT4	O	Pulled-down (50kΩ)	Output	Output
39	AVDRV	O	Pulled-down (70Ω)	Output	Output

Table 2. Internal Pulled-down Pin Status

■ Power-down Status of Output Pins

No	Pin Name	I/O	Power-down Status	No	Pin Name	I/O	Power-down Status
60	VCOM	O	"L" Output	35	SO/SDA	I/O	"Hi-Z" Output
55	MPREF	O	"L" Output				
56	MPWR1	O	"Hi-Z" Output	22	SDOUT1	O	"L" Output
57	MPWR2	O	"Hi-Z" Output	18	SDOUT2/GPO0	O	"L" Output
64	AOUT1L	O	"Hi-Z" Output	32	SDOUT3/GPO1	O	"L" Output
63	AOUT1R	O	"Hi-Z" Output	33	STO/RDY/SDOUT4	O	"L" Output
2	AOUT2L	O	"Hi-Z" Output	5	SDOUT5/GPO2	O	"L" Output
1	AOUT2R	O	"Hi-Z" Output	8	SDOUT6/DIT/GPO3	O	"L" Output
20	LRCK1	I/O	Input	7	CLKO	O	"L" Output
21	BICK1	I/O	Input	11	XTO	O	"H" Output
16	LRCK2	I/O	Input	39	AVDRV	O	"L" Output
17	BICK2	I/O	Input				
26	LRCK3/JX2	I/O	Input				
27	BICK3/JX3	I/O	Input				
28	LRCK4	I/O	Input				
29	BICK4	I/O	Input				
4	LRCK5	I/O	Input				
6	BICK5	I/O	Input				

Table 3. Power-down Status of Output Pins

■ Relationship between Power Supplies and Digital Pins

Power Supply	Digital Pins
TVDD1	SDIN1, SDIN2/JX0, SDOUT1, SDOUT2/GPO0, LRCK1, BICK1, LRCK2, BICK2
TVDD2	SDIN3/JX1, SDIN4, SDOUT3/GPO1, STO/RDY/SDOUT4, LRCK3/JX2, BICK3/JX3, LRCK4, BICK4, PDN, SCLK/SCL, SO/SDA, CSN, SI/I2CFIL
VDD33	SDIN5/JX0, SDIN6, SDOUT5/GPO2, SDOUT6/DIT/GPO3, LRCK5, BICK5, CLKO, TESTI, XTO, XTI

Table 4. Relationship between Power Supplies and Digital Pins

6. Absolute Maximum Ratings

(AVSS=DVSS1=DVSS2=DVSS3=0V; Note 3)

Parameter	Symbol	min	max	Unit
Power Supplies				
Analog	AVDD	-0.3	4.3	V
Digital1(Core)	LVDD	-0.3	4.3	V
Digital2(I/F)	TVDD1	-0.3	4.3	V
Digital3(I/F)	TVDD2	-0.3	4.3	V
Digital4(I/F)	VDD33	-0.3	4.3	V
DVSS-AVSS (Note 3)	ΔGND	-0.3	0.3	V
Input Current (except power supply pins)	IIN	—	±10	mA
Analog Input Voltage (Note 4)	VINA	-0.3	(AVDD+0.3)≤4.3	V
Digital Input Voltage (Note 5)	VIND1	-0.3	(TVDD1+0.3)≤4.3	V
Digital Input Voltage (Note 6)	VIND2	-0.3	(TVDD2+0.3)≤4.3	V
Digital Input Voltage (Note 7)	VIND3	-0.3	(VDD33+0.3)≤4.3	V
Ambient Temperature (Power applied)	Ta	-40	85	°C
Storage Temperature	Tstg	-65	150	°C

Note 3. All voltages are with respect to ground. AVSS and DVSS1-3 must be connected to the same ground.
Note 4. The maximum analog input voltage is smaller value between (AVDD+0.3)V and 4.3V.
Note 5. The maximum digital input voltage of SDIN1, SDIN2/JX0, LRCK1, BICK1, LRCK2 and BICK2 pins is smaller value between (TVDD1+0.3)V and 4.3V.
Note 6. The maximum digital input voltage of SDIN3/JX1, SDIN4, LRCK3/JX2, BICK3/JX3, LRCK4, BICK4, PDN, SCLK/SCL, SO/SDA, CSN and SI/I2CFIL pins is smaller value between (TVDD2+0.3)V and 4.3V.
Note 7. The maximum digital input voltage of SDIN5/JX0, SDIN6, LRCK5, BICK5, TESTI and XTI pins is smaller value between (VDD33+0.3)V and 4.3V.

WARNING: Operation at or beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

7. Recommended Operating Conditions

(AVSS=DVSS1=DVSS2=DVSS3=0V; Note 3)

Parameter	Symbol	min	typ	max	Unit
Power Supplies					
Analog	AVDD	3.0	3.3	3.6	V
Digital1(Core)	LVDD	3.0	3.3	3.6	V
Digital2(I/F)	TVDD1	1.7	3.3	3.6	V
Digital3(I/F)	TVDD2	1.7	3.3	3.6	V
Digital4(I/F)	VDD33	3.0	3.3	3.6	V

Note 8. The power-up sequence with AVDD, DVDD, TVDD1, TVDD2 and VDD33 is not critical. The PDN pin should be held "L" when power is supplied. The PDN pin is allowed to be "H" after all power supplies are applied and settled.
Note 9. Do not turn off the power supply of the AK7738 with the power supply of the peripheral device turned on. When using the I^2C interface, pull-up resistors of SDA and SCL pins should be connected to TVDD2 or less voltage.

WARNING: AKM assumes no responsibility for the usage beyond the conditions in the datasheet.

8. Electrical Characteristics

■ Analog Characteristics

1. MIC AMP Gain

(Ta=25°C; AVDD=LVDD=TVDD1=TVDD2=VDD33=3.3V; AVSS=DVSS1=DVSS2=DVSS3=0V)

	Parameter		min	typ	max	Unit
	Input Impedance		14	20	26	kΩ
MIC AMP	Gain	MGNL[3:0]bits=0h, MGNR[3:0]bits=0h	-1	0	1	dB
		MGNL[3:0]bits=1h, MGNR[3:0]bits=1h	1	2	3	
		MGNL[3:0]bits=2h, MGNR[3:0]bits=2h	3	4	5	
		MGNL[3:0]bits=3h, MGNR[3:0]bits=3h	5	6	7	
		MGNL[3:0]bits=4h, MGNR[3:0]bits=4h	7	8	9	
		MGNL[3:0]bits=5h, MGNR[3:0]bits=5h	9	10	11	
		MGNL[3:0]bits=6h, MGNR[3:0]bits=6h	11	12	13	
		MGNL[3:0]bits=7h, MGNR[3:0]bits=7h	13	14	15	
		MGNL[3:0]bits=8h, MGNR[3:0]bits=8h	15	16	17	
		MGNL[3:0]bits=9h, MGNR[3:0]bits=9h	17	18	19	
		MGNL[3:0]bits=Ah, MGNR[3:0]bits=Ah	20	21	22	
		MGNL[3:0]bits=Bh, MGNR[3:0]bits=Bh	23	24	25	
		MGNL[3:0]bits=Ch, MGNR[3:0]bits=Ch	26	27	28	
		MGNL[3:0]bits=Dh, MGNR[3:0]bits=Dh	29	30	31	
		MGNL[3:0]bits=Eh, MGNR[3:0]bits=Eh	32	33	34	
		MGNL[3:0]bits=Fh, MGNR[3:0]bits=Fh	35	36	37	

2. MIC Bias

(Ta=25°C; AVDD=LVDD=TVDD1=TVDD2=VDD33=3.3V; AVSS=DVSS1=DVSS2=DVSS3=0V;
Measurement Frequency =20Hz~20kHz)

	Parameter	min	typ	max	Unit
MIC Bias	Output Voltage	2.3	2.5	2.7	V
	Load Resistance	2			kΩ
	Load Capaitance			30	pF
	Output Noise (A-weighted)		-114	-108	dBV

3. MIC AMP + ADC1

(Ta=25°C; AVDD=LVDD=TVDD1=TVDD2=VDD33=3.3V; AVSS=DVSS1=DVSS2=DVSS3=0V; Signal Frequency=1kHz; 24-bit Data; BICK=64fs, Measurement Frequency=20Hz ~ 20kHz @ fs=48kHz; Measurement Frequency=20Hz ~ 40kHz @ fs=96kHz and fs=192kHz, Differential Input, Unless otherwise specified.)

	Parameter		min	typ	max	Unit
MIC AMP + ADC1	Resolution				24	Bit
	Input Voltage (Note 13)	Differential Input (Note 11)	±2.1	±2.3	±2.5	Vpp
		Differential Input (Note 12)	±0.264	±0.290	±0.315	
		Single-ended Input (Note 11)	2.1	2.3	2.5	Vpp
		Single-ended Input (Note 12)	0.264	0.290	0.315	
	S/(N+D) (-1dBFS)	fs=48kHz (Note 11)	80	90		dB
		fs=48kHz (Note 12)		82		
		fs=96kHz (Note 11)		87		
		fs=96kHz (Note 12)		79		
		fs=192kHz (Note 11, Note 14)		87		
		fs=192kHz (Note 12, Note 14)		79		
	Dynamic Range (-60dBFS)	fs=48kHz (A-weighted) (Note 11)	94	102		dB
		fs=48kHz (A-weighted) (Note 12)		90		
		fs=96kHz (Note 11)		95		
		fs=96kHz (Note 12)		87		
		fs=192kHz (Note 11)		95		
		fs=192kHz (Note 12)		87		
	S/N	fs=48kHz (A-weighted) (Note 11)	94	102		dB
		fs=48kHz (A-weighted) (Note 12)		90		
		fs=96kHz (Note 11)		95		
		fs=96kHz (Note 12)		87		
		fs=192kHz (Note 11)		95		
		fs=192kHz (Note 12)		87		
	Inter-Channel Isolation (fin=1kHz) (Note 10)		90	105		dB
	Channel Gain Mismatch			0.0	0.3	dB

Note 10. Inter-channel isolation with -1dBFS signal input.
Note 11. MGNL/R[3:0] bits = 0h (0dB). Input full-scale voltage is propotional to AVDD (0.7 x AVDD).
Note 12. MGNL/R[3:0] bits = 9h (+18dB). Input full-scale voltage is propotional to AVDD (0.088 x AVDD).
Note 13. -0.7dBFS is output when fs=192kHz and ADC1 digital filter is set to Slow Roll-Off or Short Delay Slow Roll-Off filter.
Note 14. In the case of inputting -1.6dBFS when fs=192kHz and ADC1 digital filter is set to Slow Roll-Off or Short Delay Slow Roll-Off filter.

4. ADC2

(Ta=25°C; AVDD=LVDD=TVDD1=TVDD2=VDD33=3.3V; AVSS= DVSS1=DVSS2=DVSS3=0V; Signal Frequency=1kHz; 24-bit Data, BICK = 64fs; Measurement Frequency=20Hz ~ 20kHz @ fs=48kHz; Measurement Frequency=20Hz ~ 40kHz @ fs=96kHz and fs=192kHz, Differential Input, Unless otherwise specified.)

	Parameter		min	typ	max	Unit
ADC2	Resolution				24	Bit
	Input Impedance		14	20	26	kΩ
	Input Voltage (Note 18)	Differential Input (Note 15)	±2.1	±2.3	±2.5	Vpp
		Single-ended Input (Note 16)	2.1	2.3	2.5	Vpp
		Pseudo Differential Input (Note 17)	2.1	2.3	2.5	Vpp
	S/(N+D) (-1dBFS)	fs=48kHz	80	90		dB
		fs=96kHz		87		
		fs=192kHz (Note 19)		87		
	Dynamic Range (-60dBFS)	fs=48kHz (A-weighted)	94	102		dB
		fs=96kHz		95		
		fs=192kHz		95		
	S/N	fs=48kHz (A-weighted)	94	102		dB
		fs=96kHz		95		
		fs=192kHz		95		
	Inter-Channel Isolation (fin=1kHz) (Note 10)		90	105		dB
	Channel Gain Mismatch			0.0	0.3	dB

Note 15. AIN2LP, AIN2LN, AIN2RP and AIN2RN pins.
Note 16. AIN3L, AIN3R, AIN4L and AIN4R pins.
Note 17. AIN5L and AIN5R pins.
Note 18. -0.7dBFS is output when fs=192kHz and ADC2 digital filter is set to Slow Roll-Off or Short Delay Slow Roll-Off filter.
Note 19. In the case of inputting -1.6dBFS when fs=192kHz and ADC2 digital filter is set to Slow Roll-Off or Short Delay Slow Roll-Off filter.

5. ADCM

(Ta=25°C; AVDD=LVDD=TVDD1=TVDD2=VDD33=3.3V; AVSS= DVSS1=DVSS2=DVSS3=0V; Signal Frequency=1kHz; 24-bit Data, BICK = 64fs; Measurement Frequency=20Hz ~ 20kHz @ fs=48kHz; Measurement Frequency=20Hz ~ 40kHz @ fs=96kHz and fs=192kHz, Differential Input, Unless otherwise specified.)

	Parameter		min	typ	max	Unit
ADCM	Resolution				24	Bit
	Input Impedance		14	20	26	kΩ
	Input Voltage (Note 22)	Differential Input (Note 20)	±2.1	±2.3	±2.5	Vpp
		Single-ended Input (Note 21)	2.1	2.3	2.5	Vpp
	S/(N+D) (-1dBFS)	fs=48kHz	80	90		dB
		fs=96kHz		87		
		fs=192kHz (Note 23)		87		
	Dynamic Range (-60dBFS)	fs=48kHz (A-weighted)	94	102		dB
		fs=96kHz		95		
		fs=192kHz		95		
	S/N	fs=48kHz (A-weighted)	94	102		dB
		fs=96kHz		95		
		fs=192kHz		95		

Note 20. AINMP and AINMN pins.
Note 21. AINM pin.
Note 22. -0.7dBFS is output when fs=192kHz and ADCM digital filter is set to Slow Roll-Off or Short Delay Slow Roll-Off filter.
Note 23. In the case of inputting -1.6dBFS when fs=192kHz and ADCM digital filter is set to Slow Roll-Off or Short Delay Slow Roll-Off filter.

6. DAC

(Ta=25°C; AVDD= LVDD =TVDD1=TVDD2= VDD33=3.3V; AVSS= DVSS1=DVSS2=DVSS3=0V; Signal Frequency=1kHz; 32-bit Data, BICK = 64fs; Measurement Frequency=20Hz ~ 20kHz @ fs=48kHz; Measurement Frequency=20Hz ~ 40kHz @ fs=96kHz and fs=192kHz; Unless otherwise specified.)

	Parameter		min	typ	max	Unit
DAC1 DAC2	Resolution				32	Bit
	Output Voltage (Note 24)		2.55	2.83	3.11	Vpp
	S/(N+D) (0dBFS)	fs=48kHz	80	91		dB
		fs=96kHz		89		
		fs=192kHz		89		
	Dynamic Range (-60dBFS)	fs=48kHz (A-weighted)	100	108		dB
		fs=96kHz		101		
		fs=192kHz		101		
	S/N	fs=48kHz (A-weighted)	100	108		dB
		fs=96kHz		101		
		fs=192kHz		101		
	Inter-Channel Isolation (fin=1kHz) (Note 25)		90	110		dB
	Channel Gain Mismatch			0.0	0.7	dB
	Load Resistance (Note 26)		10			kΩ
	Load Capaitance				30	pF

Note 24. The output voltage when 0dBFS signal input. The output voltage is proportional to AVDD (AVDD x 0.86).
Note 25. Inter-channel isolation between each DAC of Lch and Rch with 0dBFS signal input. (AOUT1L and AOUT1R, and AOUT2L and AOUT2R)
Note 26. to AC load

7. SRC

(Ta=25°C; AVDD=LVDD=TVDD1=TVDD2=VDD33=3.3V; AVSS= DVSS1=DVSS2=DVSS3=0V;
Signal Frequency=1kHz; 24-bit Data; Measurement Frequency=20Hz ~ FSO/2)

	Parameter	Symbol	min	typ	max	Unit
SRC	Resolution				24	Bit
	Input Sample Rate	FSI	8		192 (Note 27)	kHz
	Output Sample Rate	FSO	8		192	kHz
	THD+N (Input=1kHz, 0dBFS)					
	FSO/FSI=192kHz/48kHz			-113		dB
	FSO/FSI=192kHz/44.1kHz			-113		dB
	FSO/FSI=44.1kHz/48kHz			-112		dB
	FSO/FSI=44.1kHz/96kHz			-111		dB
	FSO/FSI=48kHz/44.1kHz			-112	-103	dB
	FSO/FSI=48kHz/96kHz			-113		dB
	FSO/FSI=48kHz/8kHz			-111		dB
	FSO/FSI=16kHz/48kHz			-113		dB
	FSO/FSI=16kHz/44.1kHz			-100		dB
	FSO/FSI=8kHz/48kHz			-113		dB
	FSO/FSI=8kHz/44.1kHz			-95		dB
	FSO/FSI=48kHz/192kHz			-105		dB
	FSO/FSI=44.1kHz/192kHz			-102		dB
	Dynamic Range (Input=1kHz, -60dBFS)					
	FSO/FSI=192kHz/48kHz			113		dB
	FSO/FSI=192kHz/44.1kHz			113		dB
	FSO/FSI=44.1kHz/48kHz			113		dB
	FSO/FSI=44.1kHz/96kHz			113		dB
	FSO/FSI=48kHz/44.1kHz		108	113		dB
	FSO/FSI=48kHz/96kHz			113		dB
	FSO/FSI=48kHz/8kHz			113		dB
	FSO/FSI=16kHz/48kHz			113		dB
	FSO/FSI=16kHz/44.1kHz			113		dB
	FSO/FSI=8kHz/48kHz			111		dB
	FSO/FSI=8kHz/44.1kHz			114		dB
	FSO/FSI=48kHz/192kHz			111		dB
	FSO/FSI=44.1kHz/192kHz			110		dB
	Dynamic Range (Input=1kHz, -60dBFS, A-weighted) FSO/FSI=44.1kHz/48kHz			115		dB
	Ratio between Input and Output Sample Rate	FSO/FSI	0.167		6	-

Note 27. Set FSI frequency of each operating SRC as the sum of the frequencies is below 384kHz. For example, if the frequency of FSI is 96kHz, four SRCs can operate at the same time, if the frequency of FSI is 192kHz, only two SRCs are allowed to operate at the same time.

8. FSCONV

(Ta=25°C; AVDD=LVDD=TVDD1=TVDD2=VDD33=3.3V; AVSS= DVSS1=DVSS2=DVSS3=0V; Signal Frequency=1kHz; 24-bit Data; Measurement Frequency=20Hz ~ FSO/2)

	Parameter	Symbol	min	typ	max	Unit
FSCONV	Resolution				24	Bit
	Input Sample Rate	FSI	44.1		48	kHz
	Output Sample Rate	FSO	8		16	kHz
	THD+N (Input=1kHz, 0dBFS)					
	FSO/FSI=16kHz/48kHz			-114		dB
	FSO/FSI=16kHz/44.1kHz			-95		dB
	FSO/FSI=8kHz/48kHz			-115		dB
	FSO/FSI=8kHz/44.1kHz			-97		dB
	Dynamic Range (Input=1kHz, -60dBFS)					
	FSO/FSI=16kHz/48kHz			114		dB
	FSO/FSI=16kHz/44.1kHz			114		dB
	FSO/FSI=8kHz/48kHz			114		dB
	FSO/FSI=8kHz/44.1kHz			114		dB
	Dynamic Range (Input=1kHz, -60dBFS, A-weighted)					
	FSO/FSI=8kHz/48kHz			117		dB
	Ratio between Input and Output Sample Rate	FSO/FSI	0.167		0.363	-

■ Power Consumption

(Ta=25°C; AVDD=3.0~3.6V(typ=3.3V, max=3.6V); LVDD=3.0~3.6V(typ=3.3V, max=3.6V); TVDD1=1.7~3.6V(typ=3.3V, max=3.6V); TVDD2=1.7~3.6V (typ=3.3V, max=3.6V); VDD33=3.0~3.6V (typ=3.3V, max=3.6V); AVSS= DVSS1=DVSS2=DVSS3=0V; fs=192kHz; BICK=64fs; SDOUT1~6/LRCK1~5/BICK1~5=Output; C_L=20pF)

Parameter	Symbol	min	typ	max	Unit
Power-Up (PDN pin= "H") (Note 28)	AVDD		26	37	mA
	LVDD		70	140	mA
	TVDD1		1.6	2.4	mA
	TVDD2		1.6	2.4	mA
	VDD33		4	6	mA
Power-Down (PDN pin= "L")	AVDD		0.01		mA
	LVDD		0.01		mA
	TVDD1		0.01		mA
	TVDD2		0.01		mA
	VDD33		0.01		mA

Note 28. The current of LVDD changes depending on the system frequency and contents of DSP program.

9. Digital Filter Characteristics

1. ADC Block

(Ta=25°C; AVDD=3.0~3.6V; LVDD=3.0~3.6V; TVDD1=1.7~3.6V; TVDD2=1.7~3.6V; VDD33=3.0~3.6V; AVSS=DVSS1=DVSS2=DVSS3=0V)

1-1 Sharp Roll-Off Filter (ADSD bit = "0", ADSL bit = "0")

fs=48kHz

Parameter		Symbol	min	typ	max	Unit
SHARP ROLL-OFF						
Passband (Note 29)	0dB ~ -0.06dB	PB	0		22.1	kHz
	-6.0dB	PB		24.4		kHz
Stopband (Note 29)		SB	27.8			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~20kHz		ΔGD		0		1/fs
Group Delay (Note 30)		GD		19		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		1.0		Hz

fs=96kHz

Parameter		Symbol	min	typ	max	Unit
SHARP ROLL-OFF						
Passband (Note 29)	0dB ~ -0.06dB	PB	0		44.2	kHz
	-6.0dB	PB		48.7		kHz
Stopband (Note 29)		SB	55.6			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~40kHz		ΔGD		0		1/fs
Group Delay (Note 30)		GD		19		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		1.9		Hz

fs=192kHz

Parameter		Symbol	min	typ	max	Unit
SHARP ROLL-OFF						
Passband (Note 29)	0dB ~ -0.04dB	PB	0		83.7	kHz
	-6.0dB	PB		100.1		kHz
Stopband (Note 29)		SB	122.9			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~40kHz		ΔGD		0		1/fs
Group Delay (Note 30)		GD		15		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		3.9		Hz

1-2 Slow Roll-Off Filter (ADSD bit = "0", ADSL bit = "1")

fs=48kHz

Parameter		Symbol	min	typ	max	Unit
SLOW ROLL-OFF						
Passband (Note 29)	0dB ~ -0.074dB	PB	0		12.5	kHz
	-6.0dB	PB		21.9		kHz
Stopband (Note 29)		SB	36.5			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~20kHz		ΔGD		0		1/fs
Group Delay (Note 30)		GD		7		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		1.0		Hz

fs=96kHz

Parameter		Symbol	min	typ	max	Unit
SLOW ROLL-OFF						
Passband (Note 29)	0dB ~ -0.074dB	PB	0		25	kHz
	-6.0dB	PB		43.7		kHz
Stopband (Note 29)		SB	73			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~40kHz		ΔGD		0		1/fs
Group Delay (Note 30)		GD		7		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		1.9		Hz

fs=192kHz

Parameter		Symbol	min	typ	max	Unit
SLOW ROLL-OFF						
Passband (Note 29)	0dB ~ -0.7dB	PB	0		49.9	kHz
	-6.0dB	PB		79.9		kHz
Stopband (Note 29)		SB	146			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~40kHz		ΔGD		0		1/fs
Group Delay (Note 30)		GD		8		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		3.88		Hz

1-3 Short Delay Sharp Roll-Off Filter (ADSD bit = "1", ADSL bit = "0")

fs=48kHz

Parameter		Symbol	min	typ	max	Unit
SHORT DELAY SHARP ROLL-OFF						
Passband (Note 29)	0dB ~ -0.06dB	PB	0		22.1	kHz
	-6.0dB	PB		24.4		kHz
Stopband (Note 29)		SB	27.8			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~20kHz		ΔGD			2.6	1/fs
Group Delay (Note 30)		GD		5		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		1.0		Hz

fs=96kHz

Parameter		Symbol	min	typ	max	Unit
SHORT DELAY SHARP ROLL-OFF						
Passband (Note 29)	0dB ~ -0.06dB	PB	0		44.2	kHz
	-6.0dB	PB		48.7		kHz
Stopband (Note 29)		SB	55.6			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~40kHz		ΔGD			2.6	1/fs
Group Delay (Note 30)		GD		5		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		1.9		Hz

fs=192kHz

Parameter		Symbol	min	typ	max	Unit
SHORT DELAY SHARP ROLL-OFF						
Passband (Note 29)	0dB ~ -0.04dB	PB	0		83.7	kHz
	-6.0dB	PB		100.1		kHz
Stopband (Note 29)		SB	122.9			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~40kHz		ΔGD			0.2	1/fs
Group Delay (Note 30)		GD		6		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		3.88		Hz

1-4 Short Delay Slow Roll-Off Filter (ADSD bit = "1", ADSL bit = "1")

fs=48kHz

Parameter		Symbol	min	typ	max	Unit
SHORT DELAY SLOW ROLL-OFF						
Passband (Note 29)	0dB ~ -0.074dB	PB	0		12.5	kHz
	-6.0dB	PB		21.9		kHz
Stopband (Note 29)		SB	36.5			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~20kHz		ΔGD			2.6	1/fs
Group Delay (Note 30)		GD		5		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		1.0		Hz

fs=96kHz

Parameter		Symbol	min	typ	max	Unit
SHORT DELAY SLOW ROLL-OFF						
Passband (Note 29)	0dB ~ -0.074dB	PB	0		25	kHz
	-6.0dB	PB		43.7		kHz
Stopband (Note 29)		SB	73			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~40kHz		ΔGD			2.6	1/fs
Group Delay (Note 30)		GD		5		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		1.9		Hz

fs=192kHz

Parameter		Symbol	min	typ	max	Unit
SHORT DELAY SLOW ROLL-OFF						
Passband (Note 29)	0dB ~ -0.7dB	PB	0		49.9	kHz
	-6.0dB	PB		77.7		kHz
Stopband (Note 29)		SB	145.9			kHz
Stopband Attenuation		SA	85			dB
Group Delay Distortion : 0Hz~40kHz		ΔGD			0.5	1/fs
Group Delay (Note 30)		GD		6		1/fs
ADC Digital Filter(HPF)						
Frequency Response	-3.0dB	FR		3.88		Hz

Note 29. The passband and stopband frequencies are proportional to fs (sampling rate). High-pass filter characteristics are not included.

Note 30. Delay time caused by the digital filter calculation. This time is measured from an analog signal input until 24-bit data of both channels are set into the output register.

2. DAC Block

(Ta= 25°C; AVDD=3.0~3.6V; LVDD=3.0~3.6V; TVDD1=1.7~3.6V; TVDD2=1.7~3.6V; VDD33=3.0~3.6V; AVSS=DVSS1=DVSS2=DVSS3=0V)

2-1 Sharp Roll-Off Filter (DASD bit = "0", DASL bit = "0")

fs=48kHz

Parameter		Symbol	min	typ	max	Unit
SHARP ROLL-OFF						
Passband (Note 31)	-0.08dB~+0.08dB	PB	0		22.2	kHz
	-6.0dB	PB		23.99		kHz
Passband Ripple		PR	-0.08		+0.08	dB
Stopband (Note 31)		SB	26.2			kHz
Stopband Attenuation		SA	69.9			dB
Group Delay (Note 32)		GD		26.4		1/fs
Digital Filter + SCF						
Frequency Response : 0Hz ~ 20kHz		FR	-0.20		0.10	dB

fs=96kHz

Parameter		Symbol	min	typ	max	Unit
SHARP ROLL-OFF						
Passband (Note 31)	-0.08dB~+0.08dB	PB	0		44.4	kHz
	-6.0dB	PB		48.00		kHz
Passband Ripple		PR	-0.08		+0.08	dB
Stopband (Note 31)		SB	52.5			kHz
Stopband Attenuation		SA	69.8			dB
Group Delay (Note 32)		GD		26.4		1/fs
Digital Filter + SCF						
Frequency Response : 0Hz ~ 40kHz		FR	-0.50		0.10	dB

fs=192kHz

Parameter		Symbol	min	typ	max	Unit
SHARP ROLL-OFF						
Passband (Note 31)	-0.08dB~+0.08dB	PB	0		88.8	kHz
	-6.0dB	PB		96.00		kHz
Passband Ripple		PR	-0.08		+0.08	dB
Stopband (Note 31)		SB	104.9			kHz
Stopband Attenuation		SA	69.8			dB
Group Delay (Note 32)		GD		26.4		1/fs
Digital Filter + SCF						
Frequency Response : 0Hz ~ 80kHz		FR	-2.00		-0.00	dB