YAMAHA LSI

YMF724F

DS-1

OVERVIEW

YMF724F (DS-1) is a high performance audio controller for the PCI Bus. DS-1 consists of two separated functional blocks. One is the PCI Audio block and the other is the Legacy Audio block. PCI Audio block allows Software Driver to handle maximum of 73 concurrent audio streams with the Bus Master DMA engine. The PCI Audio Engine converts the sampling rate of each audio stream and the streams are mixed without utilizing the CPU or causing system latency. By using the Software Driver from YAMAHA, PCI Audio provides 64-voice XG wavetable synthesizer with Reverb and variation. It also supports DirectSound hardware accelerator, Downloadable Sound (DLS) and DirectMusic accelerator.

Legacy Audio block supports FM Synthesizer, Sound Blaster Pro, MPU401 UART mode and Joystick function in order to provide hardware compatibility for numerous PC games on real DOS without any software driver. To achieve legacy DMAC compatibility on the PCI, DS-1 supports both PC/PCI and Distributed DMA protocols. DS-1 also supports Serialized IRQ for legacy IRQ compatibility.

DS-1 supports the connection to AC'97 which provides high quality DAC, ADC and analog mixing.

In addition, it supports consumer IEC958, Audio Digital Interface (SPDIF) output, for high-quality, external audio amplification.

FEATURES

- PCI 2.1 Compliant
- PC'97/PC'98 specification Compliant
- PCI Bus Power Management rev. 1.0 Compliant (Support D0, D2 and D3 state)
- PCI Bus Master for PCI Audio
  - True Full Duplex Playback and Capture with different Sampling Rate
  - Maximum 64-voice XG capital Wavetable Synthesizer including GM compatibility
  - DirectSound Hardware Acceleration
  - DirectMusic Hardware Acceleration
  - Downloadable Sound (DLS) level-1
- Legacy Audio compatibility
  - FM Synthesizer
  - Hardware Sound Blaster Pro compatibility
  - MPU401 UART mode MIDI interface
  - Joystick
- Supports PC/PCI and Distributed DMA for legacy DMAC (8237) emulation
- Supports Serialized IRQ
- Supports YAMAHA AC-3 device (YMF727 : AC3F2) interface to enable AC-3 decode
- Supports Consumer IEC958 Output (SPDIF) port
- Supports AC'97 Interface (AC-Link)
- Hardware Volume Control
- EEPROM Interface
- Single Crystal operation (24.576MHz)
- 5V Power supply for I/O. 3.3V Power supply for Internal core logic
- 144-pin LQFP (YMF724F-V)

GENERAL MIDI SONDIUS-XG™

XG Sensaura™

YAMAHA CORPORATION

YMF724F CATALOG
CATALOG No.:LSI-4MF724F20
January 14, 1999

■ Logos

GENERAL MIDI logo is a trademark of Association of Musical Electronics Industry (AMEI), and indicates GM system level 1 Compliant.

XG logo is a trademark of YAMAHA Corporation.

SONDIUS-XG logo is a trademark that Stanford University in the United States and YAMAHA Corporation hold jointly.

Sensaura logo is a trademark of Central Research Laboratories Limited.

1. GM system level 1

GM system level 1 is a world standard format about MIDI synthesizer which provides voice arrangements and MIDI functions.

2. XG

XG is a format about MIDI synthesizer that is proposed by YAMAHA, and keeps the upper compatibility of GM system level 1. The good points are the voice arrangements kept extensively, a large number of the voices, modification of the voices, 3 kinds of effects, and so on.

3. SONDIUS-XG

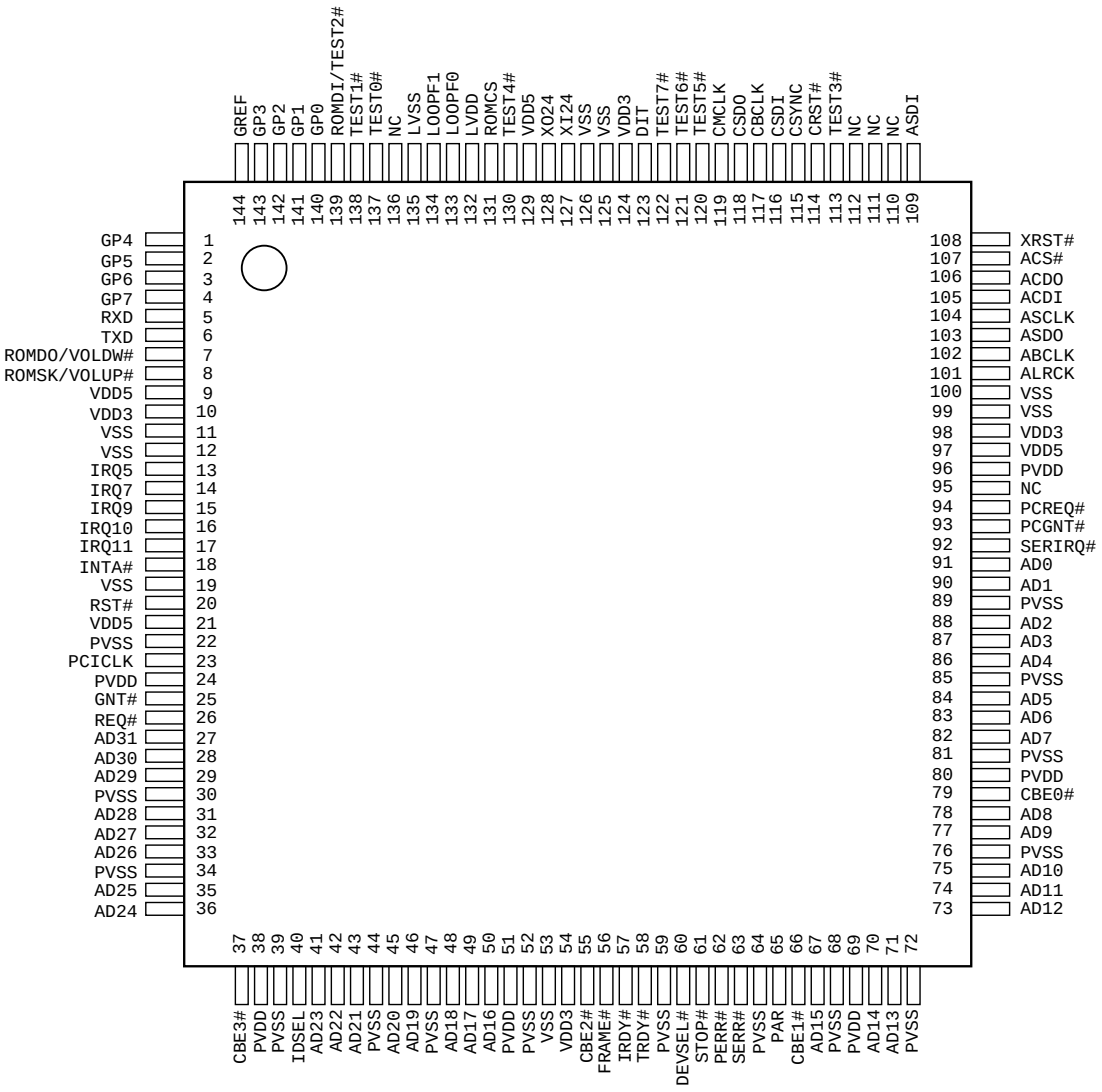
Products bearing the SONDIUS-XG logo are licensed under patents of Stanford University and YAMAHA Corporation as listed on <http://www.sondius-xg.com>. The SONDIUS-XG produces acoustic sound outputs by running a virtual simulation of the actual acoustic instrument operation. Therefore, it provides much more real-world acoustic sound outputs fundamentally different from the Wavetable sound generator that simply processes the recorded acoustic sound sources only. The SONDIUS-XG adds the technology of virtual acoustic sound to the XG format.

4. Sensaura

Sensaura is a technology which provides 3D positional audio and moving effect by HRTF (Head Related Transfer Function) with 2 speakers or headphone. This feature makes it possible to enjoy invariable and unchangeable sound feelings in all-positional area covering as wide as 360 degrees.

■ PIN CONFIGURATION

YMF724F-V



144 Pin LQFP Top View

■ PIN DESCRIPTION

1. PCI Bus Interface (53-pin)

name	I/O	Type	Size	function
PCICLK	I	P		PCI Clock
RST#	I	P		Reset
AD[31:0]	IO	Ptr		Address / Data
C/BE[3:0]#	IO	Ptr		Command / Byte Enable
PAR	IO	Ptr		Parity
FRAME#	IO	Pstr		Frame
IRDY#	IO	Pstr		Initiator Ready
TRDY#	IO	Pstr		Target Ready
STOP#	IO	Pstr		Stop
IDSEL	I	P		ID Select
DEVSEL#	IO	Pstr		Device Select
REQA#	O	P		PCI Request
GNTA#	I	P		PCI Grant
PCREQ#	O	Ptr		PC/PCI Request
PCGNT#	I	Ptr		PC/PCI Grant
PERR#	IO	Pstr		Parity Error
SERR#	O	Pod		System Error
INTA#	O	Pod		Interrupt signal output for PCI bus
SERIRQ#	IO	Ptr		Serialized IRQ.

2. AC'97 Interface (6-pin)

Name	I/O	Type	Size	function
CRST#	O	T	6mA	Reset signal for AC'97
CMCLK	O	C	-	Master Clock of AC link (24.576MHz) and AC3F2
CBCLK	I	T	-	AC-link: Bit Clock for AC'97 audio data
CSDO	O	T	6mA	AC-link: AC'97 Serial audio output data
CSDI	I	T	-	AC-link: AC'97 Serial audio input data
CSYNC	O	T	6mA	AC-link: Synchronized signal

3. YMF727(AC3F2) Interface (9-pin)

name	I/O	type	size	function
XRST#	O	C	2mA	Reset for local device
ACS#	O	T	3mA	Chip select for AC3F2
ASCLK	O	T	6mA	Clock for Serial control data transfer of AC3F2
ACDO	O	T	3mA	Serial control data output of AC3F2
ACDI	I	Tup	-	Serial control data input of AC3F2
ALRCK	O	T	3mA	L/R clock for Serial audio data of AC3F2
ABCLK	O	T	6mA	Bit clock for Serial audio data of AC3F2
ASDO	O	T	3mA	Serial audio data output to AC3F2
ASDI	I	Tup	-	Mixed Serial audio data input of AC3F2

4. SPDIF Interface (1-pin)

name	I/O	type	Size	function
DIT	O	T	3mA	Digital audio interface output (48kHz)

5. Legacy Device Interface (16-pin)

name	I/O	type	Size	function
IRQ5	O	Ttr	12mA	Interrupt5 of Legacy Audio It is directly connected to the interrupt signal of System I/O chip.
IRQ7	O	Ttr	12mA	Interrupt7 of Legacy Audio
IRQ9	O	Ttr	12mA	Interrupt9 of Legacy Audio
IRQ10	O	Ttr	12mA	Interrupt10 of Legacy Audio
IRQ11	O	Ttr	12mA	Interrupt11 of Legacy Audio.
GP[3:0]	I	A	-	Game Port
GP[7:4]	I	Tup	-	Game Port
GREF	I	A	-	Reference for Game Port
RXD	I	Tup	-	MIDI Data Receive
TXD	O	T	3mA	MIDI Data Transfer

6. Miscellaneous (15-pin)

name	I/O	type	Size	function
ROMCS	O	T	3mA	Chip select for external EEPROM
ROMSK / VOLUP#	IO	Tup	3mA	Serial clock for external EEPROM or Hardware Volume (Up)
ROMDO / VOLDW#	IO	Tup	3mA	Serial data output for external EEPROM or Hardware Volume (Down)
ROMDI / TEST2#	I	Tup	-	Serial data input for external EEPROM or Test pin (Do not connect externally when EEPROM is not.)
XI24	I	C	-	24.576 MHz Crystal
XO24	O	C	2mA	24.576 MHz Crystal
TEST[7:4,1:0]#	I	Tup	-	Test pins (Do not connect externally)
TEST3#	IO	Tup	3mA	Test pin (Connect to ground)
LOOPF[1:0]	-	-	-	Capacitor of PLL

Note) Hardware volume and EEPROM interface can not be used at the same time. When both hardware volume and EEPROM are not used, do not connect these pins externally.

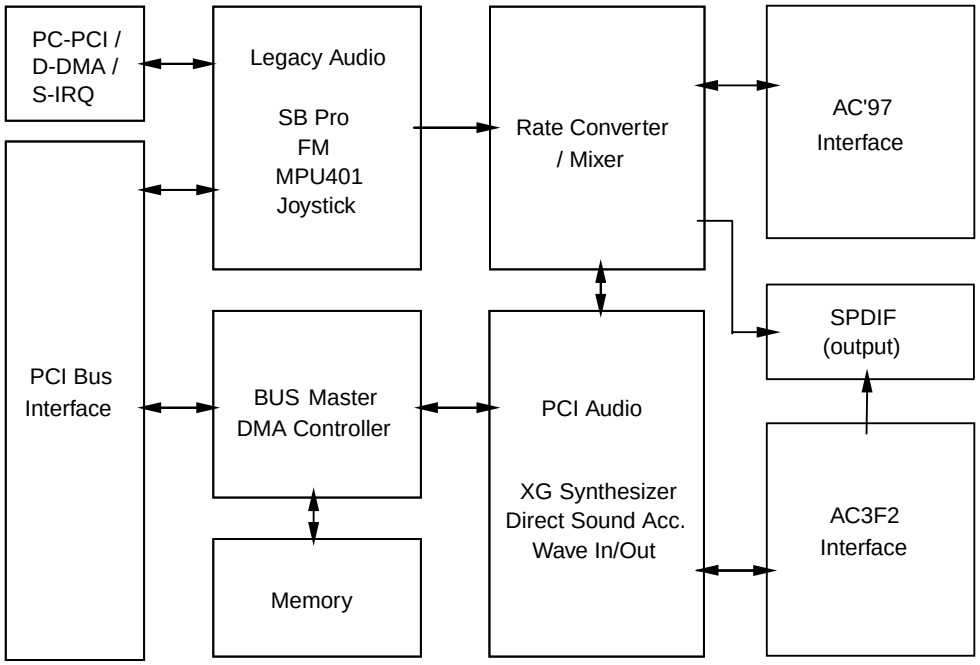
7. Power Supply (39-pin)

name	I/O	type	Size	function
PVDD[5:0]	-	-	-	Power supply for PCI Bus Interface (+5.0)
PVSS[14:0]	-	-	-	Ground for PCI Bus Interface
LVDD	-	-	-	Power supply for PLL Filter (+3.3)
LVSS	-	-	-	Ground for PLL Filter
VDD3[3:0]	-	-	-	Power supply (+3.3V)
VDD5[3:0]	-	-	-	Power supply (+5.0V)
VSS[7:0]	-	-	-	Ground

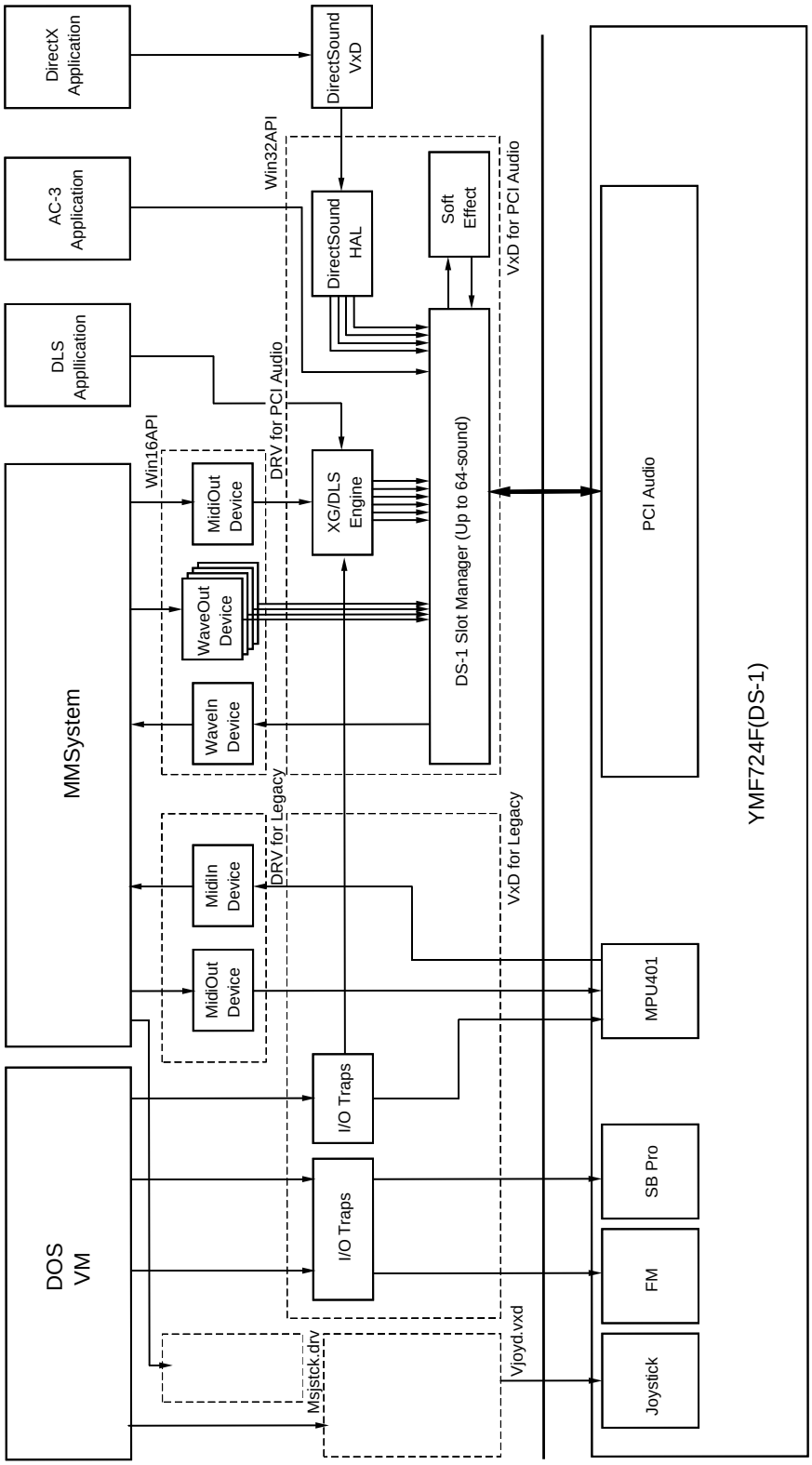
TYPE

T : TTL	A : Analog	Ptr : Tri-State PCI
Ttr : Tri-State TTL	C : CMOS	Pstr : Sustained Tri-Sate PCI
Tup : Pull up (Max. 300kohm) TTL	P : PCI	Pod : Open Drain PCI

■ BLOCK DIAGRAM



■ SYSTEM DIAGRAM



■ FUNCTION OVERVIEW

1. PCI INTERFACE

DS-1 supports the PCI bus interface and complies to PCI revision 2.1.

1-1. PCI Bus Command

DS-1 supports the following PCI Bus commands.

1-1-1. Target Device Mode

C/BE[3:0]#				Command
0	0	0	0	Interrupt Acknowledge (not support)
0	0	0	1	Special Cycle (not support)
0	0	1	0	I/O Read
0	0	1	1	I/O Write
0	1	0	0	reserved
0	1	0	1	reserved
0	1	1	0	Memory Read
0	1	1	1	Memory Write
1	0	0	0	reserved
1	0	0	1	reserved
1	0	1	0	Configuration Read
1	0	1	1	Configuration Write
1	1	0	0	Memory Read Multiple (not support)
1	1	0	1	Dual Address Cycle (not support)
1	1	1	0	Memory Read Line (not support)
1	1	1	1	Memory Write and Invalidate (not support)

DS-1 does not assert DEVSEL# when accessed with commands that are indicated as (not supported) or reserved.

1-1-2. Master Device Mode

C/BE[3:0]#				Command
0	1	1	0	Memory Read
0	1	1	1	Memory Write

When DS-1 becomes a Master Device, it generates only memory write and read cycle commands.

1-2. PCI Configuration Register

In addition to the Configuration Register defined by PCI Revision 2.1, DS-1 provides proprietary PCI Configuration Registers in order to control legacy audio function, such as FM Synthesizer, Sound Blaster Pro, MPU401 and Joystick. These additional registers are configured by BIOS or the configuration software from YAMAHA Corporation.

The following shows the overview of the PCI Configuration Register.

Offset	b[31..24]	b[23..16]	b[15..8]	b[7..0]
00-03h	Device ID		Vendor ID	
04-07h	Status		Command	
08-0Bh	Base Class Code	Sub Class Code	Programming IF	Revision ID
0C-0Fh	Reserved	Header Type	Latency Timer	Reserved
10-13h	PCI Audio Memory Base Address			
14-2Bh	Reserved			
2C-2Fh	Subsystem ID		Subsystem Vendor ID	
30-33h	Reserved			
34-37h	Reserved			Cap Pointer
38-3Bh	Reserved			
3C-3Fh	Maximum Latency	Minimum Grant	Interrupt Pin	Interrupt Line
40-43h	Extended Legacy Audio Control		Legacy Audio Control	
44-47h	Subsystem ID Write		Subsystem Vendor ID Write	
48-4Bh	DS-1 Power Control		DS-1 Control	
4C-4Fh	Reserved		D-DMA Slave Configuration	
50-53h	Power Management Capabilities		Next Item Pointer	Capability ID
54-57h	Reserved		Power Management Control / Status	
58-5Bh	Reserved		ACPI Mode	
5C-FFh	Reserved			

Reserved registers are hardwired to “0”. All data written to these registers are discarded. The values read from these registers are all zero.

DS-1 can be accessed by using any bus width, 8-bit, 16-bit or 32-bit.

00 - 01h: Vendor ID

Read Only
Default: 1073h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Vendor ID															

b[15:0].....Vendor ID

This register contains the YAMAHA Vendor ID registered in Revision 2.1. This register is hardwired to **1073h**.

02 - 03h: Device ID

Read Only
Default: 000Dh
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Device ID															

b[15:0].....Device ID

This register contains the Device ID of DS-1. This register is hardwired to **000Dh**.

04 - 05h: Command

Read / Write
Default: 0000h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
-	-	-	-	-	-	-	SER	-	PER	-	-	-	BME	MS	-

b1.....MS: Memory Space

This bit enables DS-1 to response to Memory Space Access.

"0": DS-1 ignores Memory Space Access. (default)

"1": DS-1 responds to Memory Space Access.

b2.....BME: Bus Master Enable

This bit enables DS-1 to act as a master device on the PCI bus.

"0": Do not set DS-1 to be the master device. (default)

"1": Set DS-1 to be the master device.

b6.....PER: Parity Error Response

This bit enables DS-1 responses to Parity Error.

"0": DS-1 ignores all parity errors.

"1": DS-1 performs error operation when DS-1 detects a parity error.

b8.....SER: SERR# Enable

This bit enables DS-1 to drive SERR#.

"0": Do not drive SERR#. (default)

"1": Drives SERR# when DS-1 detects an Address Parity Error on normal target cycle or a Data Parity Error on special cycle.

06 - 07h: Status

Read / Write Clear
Default: 0210h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
DPE	SSE	RMA	RTA	STA	DEVT		DPD	-	-	-	CAP	-	-	-	-

b4.....CAP: Capability (Read Only)

This bit indicates that DS-1 supports the capability register. This bit is read only. When 58-59h : ACPI Mode register, ACPI bit is "0", the bit is "1". When ACPI bit is "1", the bit is "0".

b8.....DPD: Data Parity Error Detected

This bit indicates that DS-1 detects a Data Parity Error during a PCI master cycle.

b[10:9].....DEVT: DEVSEL Timing

This bit indicates that the decoding speed of DS-1 is Medium.

b11.....STA: Signaled Target Abort

This bit indicates that DS-1 terminates a transaction with Target Abort during a target cycle.

b12.....RTA: Received Target Abort

This bit indicates that a transaction is terminated with Target Abort while DS-1 is in the master memory cycle.

b13.....RMA: Received Master Abort

This bit indicates that a transaction is terminated with Master Abort while DS-1 is in the master memory cycle.

b14.....SSE: Signaled System Error

This bit indicates that DS-1 asserts SERR#.

b15.....DPE: Detected Parity Error

This bit indicates that DS-1 detects Address Parity Error or Data Parity Error during a transaction.

08h: Revision ID

Read Only
Default: 03h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Revision ID							

b[7:0] .....Revision ID

This register contains the revision number of DS-1. This register is hardwired to **03h**.

09h: Programming Interface

Read Only
Default: 00h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Programming Interface							

b[7:0] .....Programming Interface

This register indicates the programming interface of DS-1. This register is hardwired to **00h**.

0Ah: Sub-class Code

Read Only
Default: 01h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Sub-class Code							

b[7:0] .....Sub-class Code

This register indicates the sub-class of DS-1. This register is hardwired to **01h**. DS-1 belongs to the **Audio** Sub-class.

0Bh: Base Class Code

Read Only
Default: 04h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Base Class Code							

b[7:0] .....Base Class Code

This register indicates the base class of DS-1. This register is hardwired to **04h**. DS-1 belongs to the **Multimedia** Base Class.

0Dh: Latency Timer

Read / Write
Default: 00h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Latency Timer							

b[7:0] .....Latency Timer

When DS-1 becomes a Bus Master device, this register indicates the initial value of the Master Latency Timer.

0Eh: Header Type

Read Only
Default: 00h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Header Type							

b[7:0] .....Header Type

This register indicates the device type of DS-1. This is hardwired to **00h**.

10 - 13h: PCI Audio Memory Base Address

Read / Write
Default: 00000000h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
MBA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
b31	b30	b29	b28	b27	b26	b25	b24	b23	b22	b21	b20	b19	b18	b17	b16
MBA (higher)															

b[31:15] .....MBA: Memory Base Address

This register indicates the physical Memory Base address of the PCI Audio registers in DS-1. The base address can be located anywhere in the 32-bit address space. Data in the DS-1 register is not prefetchable.

DS-1 needs 32768-bytes of memory address space.

2C-2Dh: Subsystem Vendor ID

Read Only
Default: 1073h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Subsystem Vendor ID															

b[15:0] .....Subsystem Vendor ID

This register contains the Subsystem Vendor ID. In general, this ID is used to distinguish adapters or systems made by different IHVs using the same chip by the same vendor. This register is read only. To write the IHV's Vendor ID, use 44-45h (Subsystem Vendor ID Write Register). IHVs must change this ID to their Vendor ID in the BIOS POST routine.

In case of the system such as Sound Card which BIOS can not control, this ID can be changed by connecting EEPROM externally. Then, Subsystem Vendor ID Write Register is invalid.

In case EEPROM is not externally, the default value is the YAMAHA's Vendor ID, **1073h**.

2E-2Fh: Subsystem ID

Read Only
Default: 000Dh
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Subsystem ID															

b[15:0] .....Subsystem ID

This register contains the Subsystem ID. In general, this ID is used to distinguish adapters or systems made by different IHVs using the same chip by the same vendor. This register is read only. To write the IHV's Device ID, use 46-47h (Subsystem ID Write Register). IHVs must change this ID to their ID in the BIOS POST routine.

In case of the system such as Sound Card which BIOS can not control, this ID can be changed by connecting EEPROM externally. Then, Subsystem ID Write Register is invalid.

In case EEPROM is not externally, the default value is the YAMAHA's Device ID, **000Dh**.

34h: Capability Register Pointer

Read Only
Default: 50h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Capability Register Pointer							

b[7:0] .....Capability Register Pointer

This register indicates the offset address of the Capabilities register in the PCI Configuration register when 58-59h: ACPI Mode register, ACPI bit is "0". DS-1 provides PCI Bus Power Management registers as the capabilities. The Power Management registers are mapped to 50h - 57h in the PCI Configuration register, and this register indicates "50h".

When ACPI bit is "1", this register indicates "00h".

3Ch: Interrupt Line

Read / Write
Default: 00h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Interrupt Line							

b[7:0] .....Interrupt Line

This register indicates the interrupt channel that INTA# is assigned to.

3Dh: Interrupt Pin

Read Only
Default: 01h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Interrupt Pin							

b[7:0] .....Interrupt Pin

DS-1 supports INTA# only. This register is hardwired to 01h.

3Eh: Minimum Grant

Read Only
Default: 05h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Minimum Grant							

b[7:0] .....Minimum Grant

This register indicates the length of the burst period required by DS-1.

This register is hardwired to **05h**.

3Fh: Maximum Latency

Read Only
Default: 19h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Maximum Latency							

b[7:0] .....Maximum Latency

This register indicates how often DS-1 generates the Bus Master Request.

This register is hardwired to **19h**.

40 - 41h: Legacy Audio Control

Read / Write
Default: 907Fh
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
LAD	SIEN	MPUIRQ			SBIRQ			SDMA		I/O	MIEN	MEN	GPEN	FMEN	SBEN

b0.....SBEN: Sound Blaster Enable

This bit enables the mapping of the Sound Blaster Pro block in the I/O space specified by the SBIO bits, when LAD is set to "0". The FM Synthesizer registers can be accessed via SB I/O space, while the SB block is enabled, even if FMEN is set to "0".

"0": Disable the mapping of the SB block to the I/O space

"1": Enable the mapping of the SB block to the I/O space (default)

b1.....FMEN: FM Synthesizer Enable

This bit enables the mapping of the FM Synthesizer block in the I/O space specified by the FMIO bits, when LAD is set to "0". FM Synthesizer registers can be accessed via SB I/O space, while the SB block is enabled, even if FMEN is set to "0".

"0": Disable the mapping of the FM Synthesizer block to the FMIO space

"1": Enable the mapping of the FM Synthesizer block to the FMIO space (default)

After setting FMEN to "1", about 100 msec is necessary before accessing these I/O space.

b2.....GPEN: Gameport Enable

This bit enables the mapping of the Joystick block in the I/O space specified by the JSIO bits, when LAD is set to "0".

"0": Disable the mapping of the Joystick block

"1": Enable the mapping of the Joystick block (default)

b3.....MEN: MPU401 Enable

This bit enables the mapping of the MPU401 block in the I/O space specified by the MPUIO bits, when LAD is set to "0".

"0": Disable the mapping of the MPU401 block

"1": Enable the mapping of the MPU401 block (default)

b4.....MIEN: MPU401 IRQ Enable

This bit enables the interrupt service of MPU401, when LAD is set to "0" and MEN is set to "1". MPU401 generates an interrupt signal when it receives any kind of MIDI data from the RXD pin.

"0": The MPU401 block can not use the interrupt service.

"1": The MPU401 block can use interrupt signals determined by the MPUIRQ bits. (default)

b5.....I/O: I/O Address Aliasing Control

This bit selects the number of bits to decode for the I/O address of each block.

"0": 16-bit address decode

"1": 10-bit address decode (default)

b[7:6].....SDMA: Sound Blaster DMA-8 Channel Select

These bits select the DMA channel for the Sound Blaster Pro block.

"0": DMA ch0
"1": DMA ch1 (default)
"2": reserved
"3": DMA ch3

b[10:8].....SBIRQ: Sound Blaster IRQ Channel Select

These bits select the interrupt channel for the Sound Blaster Pro block.

"0": IRQ5 (default)
"1": IRQ7
"2": IRQ9
"3": IRQ10
"4": IRQ11
"5" - "7": reserved.

b[13:11].....MPUIRQ: MPU401 IRQ Channel Select

When MIEN is set to "1", these bits select the interrupt channel for the MPU401 block.

"0": IRQ5
"1": IRQ7
"2": IRQ9 (default)
"3": IRQ10
"4": IRQ11
"5" - "7": reserved

Same interrupt channels can be assigned to SBIRQ and MPUIRQ.

b14.....SIEN: Serialized IRQ enable

DS-1 supports 3 types of interrupt protocols: PCI interrupt (INTA#), Legacy interrupt (IRQs) and Serialized IRQ. The interrupt protocol is selected with IMOD and SIEN as follows.

The interrupt channels for IRQs and Serialized IRQ are determined by SBIRQ and MPUIRQ,. Only one protocol can be used at once.

SIEN	IMOD	Interrupt protocol	
0	0	Legacy interrupt (IRQs)	(default)
0	1	PCI interrupt (INTA#)	
1	*	Serialized IRQ	

b15.....LAD: Legacy Audio Disable

This bit disables the Legacy Audio block.

"0": Enables the Legacy Audio block
"1": Disables the Legacy Audio block (default)

When this bit is set to "1", DS-1 does not respond to the I/O Target transaction for legacy I/O address on the PCI bus.

42 - 43h: Extended Legacy Audio Control

Read / Write
Default: 0000h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
IMOD	SBVER		SMOD		-	-	MAIM	JSIO		MPUIO		SBIO		FMIO	

b[1:0] .....FMIO: FM I/O Address allocation

These bits determine the base I/O address for the of the FM Synthesizer block (FMBase).
FM Synthesizer block uses 4 bytes in the I/O address space.

"0": 388h (default)
"1": 398h
"2": 3A0h
"3": 3A8h

b[3:2] .....SBIO: SB I/O Address allocation

These bits determine the base I/O address for the Sound Blaster Pro block (SBBase). This block uses 16 bytes in the I/O address space.

"0": 220h (default)
"1": 240h
"2": 260h
"3": 280h

b[5:4] .....MPUIO: MPU I/O Address allocation

These bits determine the base I/O address for the MPU401 block (MPUBase). This block uses 2 bytes in the I/O address space.

"0": 330h (default)
"1": 300h
"2": 332h
"3": 334h

b[7:6] .....JSIO: Joystick I/O Address allocation

These bits determine the base I/O address for the Joystick block (JSBase). This block uses 1 byte in the I/O address space.

"0": 201h (default)
"1": 202h
"2": 204h
"3": 205h

b8.....MAIM: MPU401 Acknowledge Interrupt Mask

This bit determine whether interrupt is asserted when the acknowledge, which is occurred by changing MPU401 mode form default to UART, is returned.

"0": Interrupt is asserted when the acknowledge is returned. (default)
"1": Interrupt is masked when the acknowledge is returned.

b[12:11].....SMOD: SB DMA mode

These bits determine the protocol to achieve the DMAC(8237) function on the PCI bus.

"0": PC/PCI (default)
"1": reserved
"2": Distributed DMA
"3" reserved

b[14:13].....SBVER: SB Version Select

These bits set the version of the SB Pro DSP. The value set in these bits is returned by sending the E1h DSP command.

"0": ver 3.01 (default)
"1": ver 2.01
"2": ver 1.05
"3": reserved

b15.....IMOD: Legacy IRQ mode

DS-1 supports 3 types of interrupt protocols: PCI interrupt (INTA#), Legacy interrupt (IRQs) and Serialized IRQ. The interrupt protocol is selected with IMOD and SIEN as follows.

SIEN	IMOD	Interrupt protocol	
0	0	Legacy interrupt (IRQs)	(default)
0	1	PCI interrupt (INTA#)	
1	*	Serialized IRQ	

44-45h: Subsystem Vendor ID Write Register

Read / Write
Default: 1073h
Access Bus Width: 16-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Subsystem Vendor ID Write															

b[15:0].....Subsystem Vendor ID Write Register

This register sets the Subsystem Vendor ID that is read from 2C-2Dh (Subsystem Vendor ID register). The default value is the YAMAHA Vendor ID, **1073h**. IHVs must change this ID to their Vendor ID in the BIOS POST routine.

In case EEPROM connects externally, this register is invalid, and do not reflect to Subsystem Vendor ID.

46-47h: Subsystem ID Write Register

Read / Write
Default: 000Dh
Access Bus Width: 16-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Subsystem ID Write															

b[15:0].....Subsystem ID Write Register

This register sets the Subsystem ID that is read from 2E-2Fh (Subsystem ID register).

The default value is the DS-1 Device ID, **000Dh**. IHVs must change this ID to their ID in the BIOS POST routine.

In case EEPROM connects externally, this register is invalid, and do not reflect to Subsystem ID.

48-49h: DS-1 Control Register

Read / Write
Default: 0001h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	XRST	CRST

b0.....CRST: AC'97 Software Reset Signal Control

This bit controls the CRST# signal.

"0": Inactive (CRST#=High)

"1": Active (CRST#=Low) (default)

b1.....XRST: Local Device Software Reset Signal Control

This bit controls the XRST# signal.

"0": Inactive (XRST#=High) (default)

"1": Active (XRST#=Low)

4A-4Bh: DS-1 Power Control Register

Read / Write
Default: 0000h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
PR7	PR6	PR5	PR4	PR3	PR2	PR1	PR0	-	-	PSN	PSL1	PSL0	DPLL1	DPLL0	DMC

b0.....DMC: Disable Master Clock Oscillation

Setting this bit to "1" disables the oscillation of the Master Clock (24.576 MHz).

"0": Normal (default)

"1": Disable

b1.....DPLL0: Disable PLL0 Clock Oscillation

Setting this bit to "1" disables the oscillation of PLL for the Legacy Audio function.

"0": Normal (default)

"1": Disable

b2.....DPLL1: Disable PLL1 Clock Oscillation

Setting this bit to "1" disables the oscillation of PLL for the PCI Audio function.

"0": Normal (default)

"1": Disable

b3.....PSL0: Power Save Legacy Audio Block 0

Setting this bit to "1" stops providing the clock with the Legacy Audio function block 0. This block includes FM Synthesizer and SB Pro engines.

"0": Normal (default)

"1": Power Save

b4.....PSL1: Power Save Legacy Audio Block 1

Setting this bit to "1" stops providing the clock with the Legacy Audio function block 1. This block includes MPU401 and Joystick.

"0": Normal (default)

"1": Power Save

b5.....PSN: Power Save PCI Audio block

Setting this bit to "1" stops providing the clock with the PCI Audio function block. This block includes PCI Audio, SRC, AC3F2 I/F, AC'97 I/F, H/W Vol. and SPDIF.

"0": Normal (default)

"1": Power Save

b8.....PR0: AC'97 Power down Control 0

This bit controls the power state of the **ADC and Input Mux** in AC'97.

"0": Normal (default)

"1": Power down

b9.....PR1: AC'97 Power down Control 1

This bit controls the power state of the **DAC** in AC'97.

"0": Normal (default)

"1": Power down

b10.....PR2: AC'97 Power down Control 2

This bit controls the power state of the **Analog Mixer (Vref still on)** in AC'97. This power state retains the Reference Voltage of AC'97.

"0": Normal (default)

"1": Power down

b11.....PR3: AC'97 Power down Control 3

This bit controls the power state of the **Analog Mixer (Vref off)** in AC'97. This power state removes Reference Voltage of AC'97.

"0": Normal (default)

"1": Power down

b12.....PR4: AC'97 Power down Control 4

This bit controls the power state of the **AC-link** in AC'97.

"0": Normal (default)

"1": Power down

b13.....PR5: AC'97 Power down Control 5

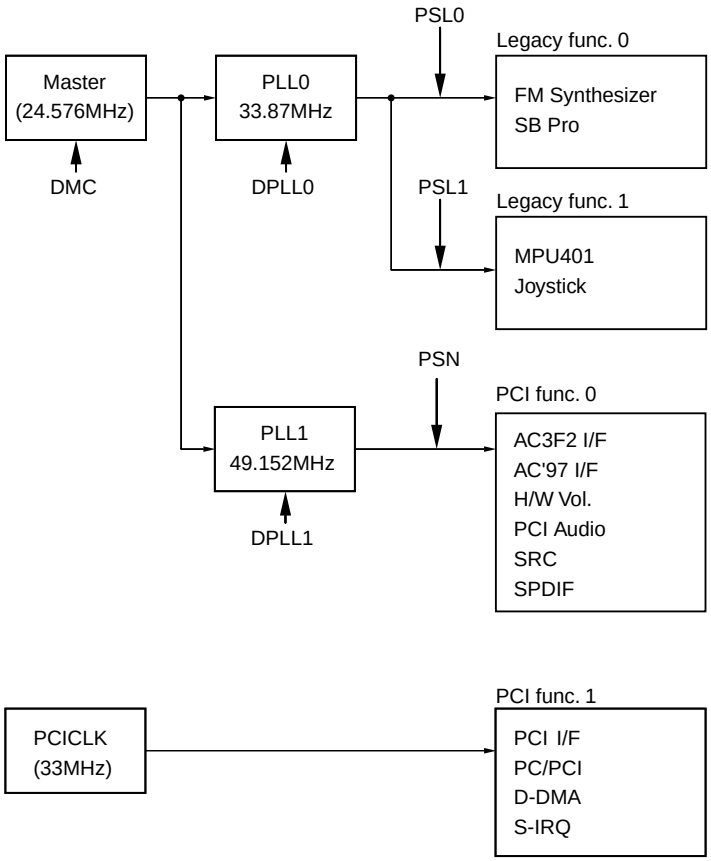
Setting this bit to "1" disables the internal clock of AC'97. In case AC'97 is used with DS-1, the master clock is supplied from DS-1. Therefore, when the clock of AC'97 is stopped completely, set both PR5 and PSN bits to "1".

"0": Normal (default)

"1": Disable

b[15:14].....AC'97 Power down Control 6 and 7

These bits control PR6 and PR7 status of the power control register in AC'97.



- Set DPLL0, DPLL1, PSL0, PSL1 and PSN bits to "1", when DMC bit is set to "1".
- Set PSL0 and PSL1 bits to "1", when DPLL0 bit is set to "1".
- Set PSN bit to "1", when DPLL1 bit is set to "1".

4C-4Dh: D-DMA Slave Configuration

Read / Write
Default: 0000h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
Base Address												EA	TS		CE

b0.....CE: Channel Enable

This bit enables the Distributed DMA function.

"0": Disable Distributed DMA (default)

"1": Enable Distributed DMA

b[2:1].....TS: Transfer Size

These bits indicate the size of the DMA transfer. Since DS-1 supports only 8-bit DMA transfer, the bits are hardwired to 00b.

b3.....EA: Extended Address

DS-1 does not support extended address mode. This bit is hardwired to 0b.

b[15:4].....Base Address : D-DMA Slave Base Address

These bits indicate the D-DMA slave base address.

50h: Capability ID

Read Only
Default: 01h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Capability ID							

b[7:0].....Capability ID: Capability Identifier

This register indicates that the new capability register is for Power Management control. This register is hardwired to **01h**.

51h: Next Item Pointer

Read Only
Default: 00h
Access Bus Width: 8, 16, 32-bit

b7	b6	b5	b4	b3	b2	b1	b0
Next Item Pointer							

b[7:0].....Next Item Pointer

DS-1 does not provide other new capability besides Power Management. This register is hardwired to **00h**.

52-53h: Power Management Capabilities

Read Only
Default: 0401h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
-	-	-	-	-	D2S	D1S	-	-	-	-	-	-	Version		

b[2:0].....Version

These bits contain the revision number of the Power Management Interface Specification. They are hardwired to **001b**.

b9.....D1S: D1 Support

This bit indicates whether DS-1 support "D1" of the power state. Only when EEPROM connects externally, this bit can be set to "1", and D1 state can support. When EEPROM does not connect externally, use ACPI mode (58-59h: ACPI Mode Register, ACPI bit) to support D1 state.
The default value is "0".

b10.....D2S: D2 Support

This bit indicates that DS-1 support "D2" of the power state. It is hardwired to "1".

54-55h: Power Management Control / Status

Read / Write
Default: 0000h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	PS	

b[1:0].....PS: Power State

These bits determine the power state of DS-1. DS-1 supports the following power states:

"0": D0

"1": D1 (not supported)

"2": D2

"3": $D3_{hot}$

When the power state is changed from $D3_{hot}$ to D0, DS-1 resets the PCI Configuration register 00-3Fh. DS-1 transits to D0 Uninitialized state.

Though the power state of this register is changed, the power consumption of DS-1 is not changed. To support low power, Windows driver controls DS-1 Power Control Register.

DS-1 can support the power state of D0, D1, D2 and D3 with ACPI. In this case, set ACPI bit (58-59h: ACPI Mode Register) to "1" to disable Capabilities of PCI Bus Power Management.

58-59h: ACPI Mode

Read / Write
Default: 0000h
Access Bus Width: 8, 16, 32-bit

b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ACPI

b0.....ACPI: ACPI Mode Select

This bit select either PCI Bus Power Management or ACPI Mode for power management of DS-1.

"0": PCI Bus Power Management is used. CAP bit (06-07h: Status Register) and Capabilities Pointer (34h) are enabled. (default)

"1": ACPI Mode is used. CAP bit and Capabilities Pointer are hardwired "0", and disabled.

2. ISA Compatible Device

DS-1 contains the following functions to maintain the compatibility with the past ISA Sound Devices. These devices are considered Legacy devices and the functions are referred to as Legacy Audio.
Legacy Audio is independent from PCI Audio and can be used simultaneously.
The configuration is set in the Legacy Audio Control Register in the PCI Configuration Register space.
Basically, these registers are configured by the BIOS.
Also, logical device IDs are assigned to the devices to support Plug and Play. Yamaha defines the following logical IDs.
To control the device with the BIOS, the logical device IDs must be defined in the PnP BIOS extended ROM space. The logical IDs are determined by how it is configured. IDs and configuration are as follows.

Logical Device ID	Functions used (Block)			
	FM (*)	MPU401	SB Pro (*)	Joystick
YMH0100	O	O	O	
YMH0101				O

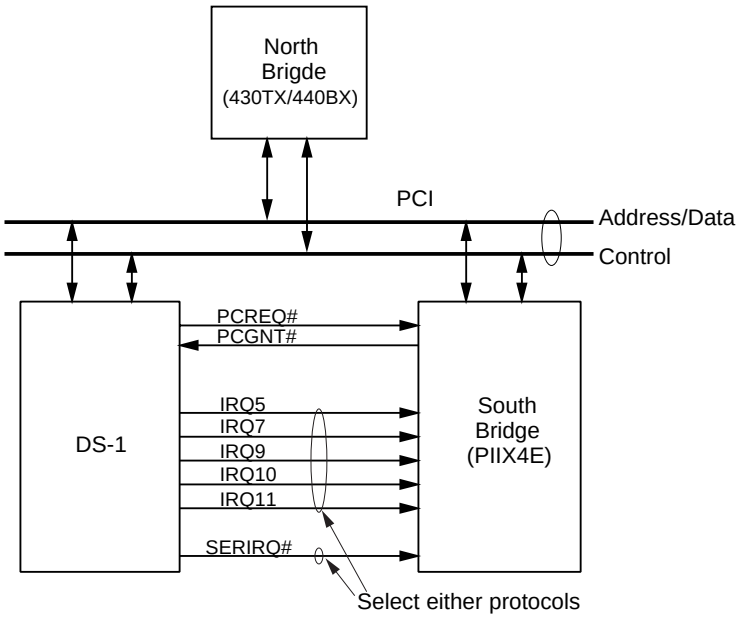
* The blocks pertain to the following.
FM: Points to the FM synthesizer mapped to AdLibBase (0x0388).
SB Pro: Points to the Voice Playback section only.

These devices are independent from each other, and can be Enabled/Disabled individually. However, both AdLib and Sound Blaster must be disabled to disable the internal FM Synthesizer. Disabling just AdLib only masks the access.

The driver by Yamaha supports only logical device ID, YMH0100. For YMH0101, use the driver provided by Microsoft.

DS-1 supports PC/PCI and D-DMA protocols to emulate the DMA of SB Pro on the PCI. In addition, DS-1 supports the old type of interrupts used by ISA and the Serialized IRQ protocol.

Yamaha recommends the combination of PC/PCI and Serialized IRQ. The system block diagram when using Intel chip set is shown below.



The PCI-to-ISA bridge needs to support PC/PCI. IRQ is directly connected to the IRQ input pins on the PCI-to-ISA bridge.

2-1. FM Synthesizer Block

FM Synthesizer Block is register compatible with YMF289B. However, Power Management register has been deleted because it is now controlled by the PCI Configuration Register.

The following shows the FMBase I/O map of FM Synthesizer.

FMBase	(R)	Status Register port
FMBase	(W)	Address port for Register Array 0
FMBase+1	(R/W)	Data port
FMBase+2	(W)	Address port for Register Array 1
FMBase+3	(R/W)	Data port

The default FMBase value is 0x0388.

The following shows the FM Synthesizer Block registers.

2-1-1. Status Register

FM Synthesizer Status Register (RO):

Address	D7	D6	D5	D4	D3	D2	D1	D0
xxh	IRQ	FT1	FT2	-	-	BUSY	-	BUSY

2-1-2. FM Synthesizer Data Register

FM Synthesizer Data Register Array 0 (R/W):

Address	D7	D6	D5	D4	D3	D2	D1	D0
00-01h	LSI TEST							
02h	TIMER 1							
03h	TIMER 2							
04h	RST	MT1	MT2	-	-	-	ST2	ST1
08h	-	NTS	-	-	-	-	-	-
20-35h(*1)	AM	VIB	EGT	KSR	MULT			
40-55h(*2)	KSL		TL					
60-75h(*3)	AR				DR			
80-95h(*4)	SL				RR			
A0-A8h	F-NUM (L)							
B0-B8h	-	-	KON	BLOCK			F-NUM (H)	
BDh	DAM	DVB	RHY	BD	SD	TOM	TC	HH
C0-C8h	*6	*6	CHR	CHL	FB			CNT
E0-F5h(*5)	-	-	-	-	-	WS		

FM Synthesizer Data Register Array 1 (R/W)

Address	D7	D6	D5	D4	D3	D2	D1	D0
00-01h	LSI TEST							
04h	-	-	CONNECTION SEL					
05h	-	-	-	-	-	*	*	NEW
20-35h(*1)	AM	VIB	EGT	KSR	MULT			
40-55h(*2)	KSL		TL					
60-75h(*3)	AR				DR			
80-95h(*4)	SL				RR			
A0-A8h	F-NUM (L)							
B0-B8h	-	-	KON	BLOCK			F-NUM (H)	
C0-C8h	*6	*6	CHR	CHL	FB			CNT
E0-F5h(*5)	-	-	-	-	-	WS		

*1 : 26h, 27h, 2Eh and 2Fh do not exist.
*2 : 46h, 47h, 4Eh and 4Fh do not exist.
*3 : 66h, 67h, 6Eh and 6Fh do not exist.
*4 : 86h, 87h, 8Eh and 8Fh do not exist.
*5 : E6h, E7h, EEh and EFh do not exist.
*6 : The bits exist, but do not function.

2-2. Sound Blaster Pro Block

This block emulates the DSP commands of Sound Blaster and Sound Blaster Pro. Only playback functions are supported (record functions are not supported). However, to maintain compatibility for games, it is designed so that every DSP command receives a correct response.
The DMA transfer of this block uses PC/PCI or D-DMA protocol.

The following shows the SBBase I/O map of SB Pro.

SBBase	(R)	FM Synthesizer Status port
SBBase	(W)	FM Synthesizer Address port for Register Array 0
SBBase+1h	(R/W)	FM Synthesizer Data register
SBBase+2h	(W)	FM Synthesizer Address port for Register Array 1
SBBase+3h	(R/W)	FM Synthesizer Data port
SBBase+4h	(W)	SB Mixer Address port
SBBase+5h	(R/W)	SB Mixer Data port
SBBase+6h	(W)	SB DSP Reset port
SBBase+8h	(R)	FM Synthesizer Status port
SBBase+8h	(W)	FM Synthesizer Address port for Register Array 0
SBBase+9h	(R/W)	FM Synthesizer Data port
SBBase+Ah	(R)	DSP Read Data port
SBBase+Ch	(R)	DSP Write-buffer status port
SBBase+Ch	(W)	DSP Write Command/Data port
SBBase+Eh	(R)	DSP Read-buffer status port

2-2-1. DSP Command

The following shows the list of DSP Commands that are supported by the SB Pro engine. Both SB and SB Pro commands are supported.

CMD	Support	Function
10h	o	8bit direct mode single byte digitized sound output
14h	o	8bit single-cycle DMA mode digitized sound output
16h		8bit to 2bit ADPCM single-cycle DMA mode digitized sound output
17h		8bit to 2bit ADPCM single-cycle DMA mode digitized sound output with ref. byte
1Ch	o	8bit auto-init DMA mode digitized sound output
1Fh		8bit to 2bit ADPCM auto-init DMA mode digitized sound output with ref. byte
20h(*1)	o	8bit direct mode single byte digitized sound input
24h(*1)	o	8bit single-cycle DMA mode digitized sound input
2Ch(*1)	o	8bit auto-init DMA mode digitized sound input
30h	o	Polling mode MIDI input
31h	o	Interrupt mode MIDI input
34h	o	UART polling mode MIDI I/O
35h	o	UART interrupt mode MIDI I/O
36h(*2)	o	UART polling mode MIDI I/O with time stamping
37h(*2)	o	UART interrupt mode MIDI I/O with time stamping
38h	o	MIDI output
40h	o	Set digitized sound transfer Time Constant
48h	o	Set DSP block transfer size
74h	o	8bit to 4bit ADPCM single-cycle DMA mode digitized sound output
75h	o	8bit to 4bit ADPCM single-cycle DMA mode digitized sound output with ref. byte
76h		8bit to 3bit ADPCM single-cycle DAM mode digitized sound output
77h		8bit to 3bit ADPCM single-cycle DMA mode digitized sound output with ref. byte
7Dh	o	8bit to 4bit ADPCM auto-init DMA mode digitized sound output with ref. byte
7Fh		8bit to 3bit ADPCM auto-init DMA mode digitized sound output with ref. byte
80h	o	Pause DAC for a duration
90h	o	8bit high-speed auto-init DMA mode digitized sound output
91h	o	8bit high-speed single-cycle DMA mode digitized sound output
98h(*1)	o	8bit high-speed auto-init DMA mode digitized sound input
99h(*1)	o	8bit high-speed single-cycle DMA mode digitized sound input
A0h(*1)	o	Set input mode to mono
A8h(*1)	o	Set input mode to stereo
D0h	o	Pause 8bit DMA mode digitized sound I/O
D1h(*3)	o	Turn on speaker
D3h(*3)	o	Turn off speaker
D4h	o	Continue 8bit DMA mode digitized sound I/O
D8h	o	Get speaker status
DAh	o	Exit 8bit auto-init DMA mode digitized sound I/O
E1h	o	Get DSP version number

Note:

(*1) The SB Block responds correctly to the commands for recording and also executes the DMA transfer. 80h is always transferred.

(*2) Only output is supported for this command.

(*3) This command only changes Speaker Status (D8h).

Undocumented commands other than the ones listed above are also supported.

2-2-2. Sound Blaster Pro Mixer

The following shows the register map of the Mixer section of Sound Blaster Pro.

Address	b7	b6	b5	b4	b3	b2	b1	b0	Remark
00h	Reset								
04h	Voice Volume L			"1"	Voice Volume R			"1"	SB Pro Mixer
0Ah	-	-	-	"1"	-	MIC Volume*			
0Ch	-	-	Ifilter*	"1"	Input Source*			"1"	
0Eh	-	-	Ofilter*	"1"	-	-	St. SW	"1"	
22h	Master Volume L			"1"	Master Volume R			"1"	
26h	MIDI Volume L			"1"	MIDI Volume R			"1"	
28h	CD Volume L*			"1"	CD Volume R*			"1"	
2Eh	Line Volume L*			"1"	Line Volume R*			"1"	
F0h	SBPDA	-	-	-	SS	SM	SE	SBPDR	Suspend / Resume
F1h	SCAN DATA								
F8h	-	-	-	-	-	-	-	SBI	IRQ Status

The registers marked with * exist, but do not function.

DS-1 does not have the circuit that corresponds to the SB Mixer. Therefore, the volume settings on the SB Mixer are converted to the DSP coefficients of DS-1 or to AC'97 register values.
The conversion for each case is described below.

(1) SB Mixer → DSP

The volume of master, MIDI and Voice, are applied to this case.
When the SB register is set, a 14-bit coefficient value is determined from the following conversion table and used as the DSP coefficient. The attenuation value of Master Volume, MIDI, and voice are summed together to obtain the coefficient.
These volumes cannot be controlled from PCI Audio block.

(1) Volume for MIDI

		MIDI Vol. (26h)							
		0	1	2	3	4	5	6	7
Master Vol. (22h)	0	mute	mute	mute	mute	mute	mute	mute	mute
		0000h	0000h	0000h	0000h	0000h	0000h	0000h	0000h
	1	mute	-52dB	-42dB	-36dB	-32dB	-30dB	-28dB	-26dB
		0000h	0029h	0082h	0103h	019Bh	0206h	028Ch	0335h
	2	mute	-42dB	-32dB	-26dB	-22dB	-20dB	-18dB	-16dB
		0000h	0082h	019Bh	0335h	0515h	0666h	080Eh	0A24h
	3	mute	-36dB	-26dB	-20dB	-16dB	-14dB	-12dB	-10dB
		0000h	0103h	0335h	0666h	0A24h	0CC5h	1013h	143Dh
	4	mute	-32dB	-22dB	-16dB	-12dB	-10dB	-8dB	-6dB
		0000h	019Bh	0515h	0A24h	1013h	143Dh	197Ah	2013h
	5	mute	-30dB	-20dB	-14dB	-10dB	-8dB	-6dB	-4dB
		0000h	0206h	0666h	0CC5h	143Dh	197Ah	2013h	2861h
	6	mute	-28dB	-18dB	-12dB	-8dB	-6dB	-4dB	-2dB
		0000h	028Ch	080Eh	1013h	197Ah	2013h	2861h	32D6h
	7	mute	-26dB	-16dB	-10dB	-6dB	-4dB	-2dB	0dB
		0000h	0335h	0A24h	143Dh	2013h	2861h	32D6h	3FFFh

The default is Master = 4, MIDI = 4 (-12dB).

(2) Volume for Voice

		Voice Vol. (04h)							
		0	1	2	3	4	5	6	7
Master Vol. (22h)	0	mute	mute	mute	mute	mute	mute	mute	mute
		0000h	0000h	0000h	0000h	0000h	0000h	0000h	0000h
	1	mute	-56dB	-46dB	-40dB	-36dB	-34dB	-32dB	-30dB
		0000h	0019h	0052h	00A3h	0103h	0146h	019Bh	0206h
	2	mute	-46dB	-36dB	-30dB	-26dB	-24dB	-22dB	-20dB
		0000h	0052h	0103h	0206h	0335h	0409h	0515h	0666Eh
	3	mute	-40dB	-30dB	-24dB	-20dB	-18dB	-16dB	-14dB
		0000h	00A3h	0206h	0409h	0666h	080Eh	0A24h	0CC5h
	4	mute	-36dB	-26dB	-20dB	-16dB	-14dB	-12dB	-10dB
		0000h	0103h	0335h	0666h	0A24h	0CC5h	1013h	143Dh
	5	mute	-34dB	-24dB	-18dB	-14dB	-12dB	-10dB	-8dB
		0000h	0146h	0409h	080Eh	0CC5h	1013h	143Dh	197Ah
	6	mute	-32dB	-22dB	-16dB	-12dB	-10dB	-8dB	-6dB
		0000h	019Bh	0515h	0A24h	1013h	143Dh	197Ah	2013h
	7	mute	-30dB	-20dB	-14dB	-10dB	-8dB	-6dB	-4dB
		0000h	0206h	0666h	0CC5h	143Dh	187Ah	2013h	2861h

The default is Master = 4, Voice = 4 (-16dB).

(2) SB Mixer → AC'97

The volume of CD, Line and MIC are applied to this case. AC'97 volume are not updated automatically when these values are changed. Thus, the SB Mixer values need to be written to the AC'97 register with the software.

2-2-3. SB Suspend / Resume

The SB block can read the internal state as to support Suspend and Resume functions. The internal state is made up of 218 flip flops. To read the state, these states are shifted in order and read 8 bits at a time from the SCAN DATA register.

These registers are mapped to the SB Mixer space (see SB Mixer Register map). The registers have the following functions.

F0h: Scan In/ Out Control

Read / Write
Default: 00h

b7	b6	b5	b4	b3	b2	b1	b0
SBPDA	-	-	-	SS	SM	SE	SBPDR

b0.....SBPDR: Sound Blaster Power Down Request

This bit stops the internal state of the Sound Blaster block.

"0": Normal (default)

"1": Stop

b1.....SE: Scan Enable

This bit Shifts the internal state by 1 bit. Setting a "1" followed by a "0" shifts the internal state.

b2.....SM: Scan Mode

This bit sets whether to read or write the state.

"0": Write (default)

"1": Read

b3.....SS: Scan Select

This bit gives permission to read or write the internal data to the SCAN DATA register.

"0": Normal operation (Do not allow read or write). (default)

"1": Allow read and write.

b7.....SBPDA: Sound Blaster Power Down Acknowledgement

This bit indicates that the SB Block is ready to read or write to the internal state after setting SBPDR. This bit is read only.

"0": Read/Write not possible

"1": Read/ Write possible

F1h: Scan In/ Out Data

Read / Write
Default: 00h

b7	b6	b5	b4	b3	b2	b1	b0
SCAN DATA							

b[7:0].....SCAN DATA

This is the data port for reading and writing the internal state.

F8h: Interrupt Flag Register

Read Only
Default: 00h

b7	b6	b5	b4	b3	b2	b1	b0
-	-	-	-	-	-	-	SBI

b0.....SBI: SB Interrupt Flag

This bit indicates that the SB DSP occurs the interrupt. This bit is read only. Thus, read the SB DSP read port to clearing the interrupt and this bit. Then, the value of the read port is invalid.

2-3. MPU401

This block is for transmitting and receiving MIDI data. It is compatible with UART mode of “MPU401”. Full duplex operation is possible using the 16-byte FIFO for each direction, transmitting and receiving.

The following shows the MPUBase I/O map for MPU401.

MPUBase	(R/W)	MIDI Data port
MPUBase + 1h	(R)	Status Register port
MPUBase + 1h	(W)	Command Register port

port	D7	D6	D5	D4	D3	D2	D1	D0
+0h	Data							
+1h (W)	Command							
+1h (R)	/DSR	/DRR	-	-	-	-	-	-

2-4. Joystick

JSBase (R/W)

port	D7	D6	D5	D4	D3	D2	D1	D0
+0h	JBB2	JBB1	JAB2	JAB1	JBCY	JBCX	JACY	JACX

JACX... Joystick A, Coordinate X
JACY... Joystick A, Coordinate Y
JBCX... Joystick B, Coordinate X
JBCY... Joystick B, Coordinate Y
JAB1... Joystick A, Button 1
JAB2... Joystick A, Button 2
JBB1... Joystick B, Button 1
JBB2... Joystick B, Button 2

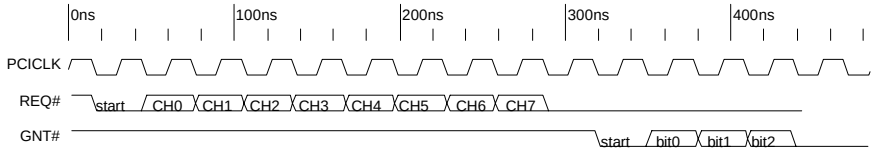
3. DMA Emulation Protocol

The former synthesizer LSI for the ISA bus such as the Sound Blaster used the DMA controller (8237: ISA DMAC) on the system to transfer the sound data from/to the host.
For DS-1, however, ISA DMAC must be used to transfer the sound data to the Sound Blaster Pro Block of the Legacy Audio Block.
Because signals to connect to the ISA DMAC are generally not available on the PCI bus, there are two ways proposed from the industry to emulate the ISA DMAC on the PCI bus. One is PC/PCI and the other is D-DMA.
DS-1 supports both protocols for transferring SB Pro sound data on the PCI bus.

3-1. PC/PCI

DS-1 provides two signals, PCREQ# and PCGNT# to realize the PC/PCI. The format of the signals is shown below. DS-1 asserts PCREQ# and sets PCREQ# to "HIGH" using the PCICLK corresponding to the DMA channel it is going to use.

In addition, DS-1 determines whether the next PCI I/O cycle is its own from the channel information that is encoded in PCGNT#.



PCGNT# is encoded as follows.

GNT# Encoding			
bit2	**bit1**	**bit0**	GNT# Bits
0	**0**	**0**	DMA Channel 0
0	**0**	**1**	DMA Channel 1
0	**1**	**0**	DMA Channel 2
0	**1**	**1**	DMA Channel 3
1	**0**	**0**	Reserved
1	**0**	**1**	DMA Channel 5
1	**1**	**0**	DMA Channel 6
1	**1**	**1**	DMA Channel 7

DS-1 supports only 8-bit DMA channels (DMA Channel 0-3). It also only supports Single DMA transfer.

3-2. D-DMA

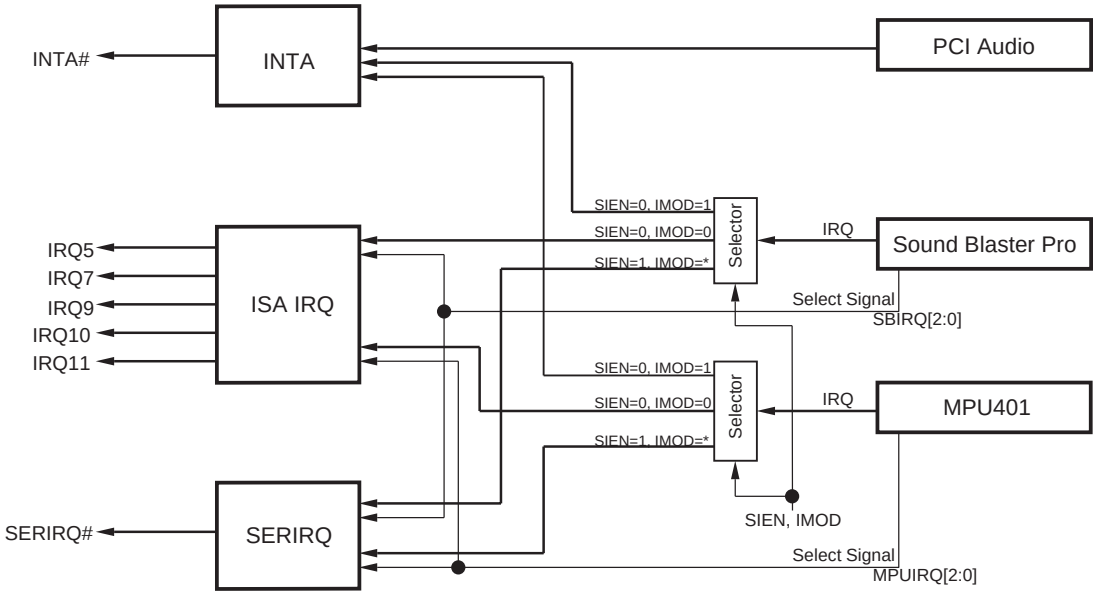
DS-1 provides the following registers to support D-DMA. D-DMA Slave Configuration Register (4C-4Dh) of the PCI Configuration register is used to set the Base address of the Slave Address.

Slave Address	R/W	Register Name
Base + 0h	W	Base Address 0-7
Base + 0h	R	Current Address 0-7
Base + 1h	W	Base Address 8-15
Base + 1h	R	Current Address 8-15
Base + 2h	W	Base Address 16-23
Base + 2h	R	Current Address 16-23
Base + 3h	W	Base Address 24-31
Base + 3h	R	Current Address 24-31
Base + 4h	W	Base Word Count 0-7
Base + 4h	R	Current Word Count 0-7
Base + 5h	W	Base Word Count 8-15
Base + 5h	R	Current Word Count 8-15
Base + 6h	W	Base Word Count 16-23
Base + 6h	R	Current Word Count 16-23
Base + 7h	N/A	Reserved
Base + 8h	W	Command
Base + 8h	R	Status
Base + 9h	W	Request
Base + Ah	N/A	Reserved
Base + Bh	W	Mode
Base + Ch	W	Reserved
Base + Dh	W	Master Clear
Base + Eh	N/A	Reserved
Base + Fh	R/W	Multi-Channel Mask

These registers can be accessed by 8-bit or 16-bit bus width.
DS-1 supports 8-bit DMA transfer only.

4. Interrupt Routing

DS-1 supports three types of interrupts, interrupt signal on the PCI bus (INTA#), interrupt signal on the ISA bus (IRQ[5,7,9,10,11]), and Serialized IRQ.
The IRQs on DS-1 are routed as shown below.



PCI Audio can only use INTA#, but the Sound Blaster Pro and MPU401 blocks of the Legacy Audio Block can use any of the three protocols.
The protocol can be switched using 40-43h (Legacy Audio Control Register) of the PCI Configuration Register.

4-1. Serialized IRQ

Serialized IRQ is a method to encode IRQs of 15 channels into one signal.

DS-1 provides the SERIRQ# pin to support Serialized IRQ.
Only one channel out of the 5 channels, IRQ5, IRQ7, IRQ9, IRQ10, and IRQ11, can be encoded into the IRQ/Data frame of Serialized IRQ.
The IRQ channel is selected using 40h-43h (Legacy Audio Control Register) of the PCI Configuration Register.

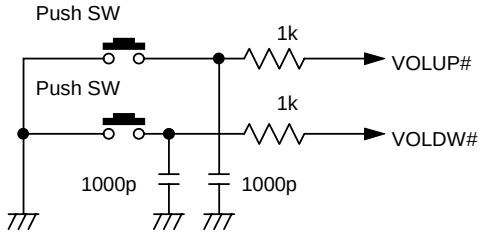
5. Digital Audio Interface

DS-1 only supports SPDIF output conforming to IEC958. The only supported Fs is 48 kHz. It can be selectable from the Dolby Digital (AC-3) encoded data or the result of Digital Mixing.

6. Hardware Volume Control

The hardware volume control determines the AC'97 master volume without using any software control using the external circuit listed below.

Two pins, VOLUP# for increasing the volume and VOLDW# for decreasing the volume, are used.



DS-1 provides a shadow register for the AC'97 master volume. When the software accesses the AC'97 Master Volume, it is always reflected in the shadow register.

The value of the shadow register is incremented by 1.5dB on the rising edge of the signal input to the VOLUP# pin. If it is already set to the maximum value, it does not change. The value set in the shadow register automatically updates the AC'97 master volume register through the AC-Link.

The value of the shadow register is decremented by 1.5dB on the rising edge of the signal input to the VOLDW# pin. If it is already set to the minimum value, it does not change. The value set in the shadow register automatically updates the AC'97 master volume register through the AC-Link.

Also, when both VOLUP#, VOLDW# pins are at LOW level, the MUTE bit of the shadow address is enabled and the Master Volume Mute bit of the AC'97 register is automatically set through the AC-Link. When a rising edge is detected on either VOLUP# or VOLDW#, the MUTE bit is reset through the AC-Link. The Master Volume is set to the value before the Mute.

If the AC-Link is BUSY (when controlling the register from the AC'97 Control Register), the value in the shadow register is set to AC'97 on the next frame. The AC'97 Control Register is set to BUSY in this case.

When the master volume changes or is muted due to VOLUP#, VOLDW#, an interrupt is generated at the host.

The interrupt is used to notify the driver that the Master Volume has been changed from the outside.

■ ELECTRICAL CHARACTERISTICS

1. Absolute Maximum Ratings

Item	Symbol	Min.	Max.	Unit
Power Supply Voltage 1 (PVDD, VDD5)	V_{DD5}	-0.5	7.0	V
Power Supply Voltage 2 (VDD3, LVDD)	V_{DD3}	-0.3	4.6	V
Input Voltage 1 (PVDD, VDD5)	V_{IN5}	-0.5	V_{DD5}+0.5	V
Input Voltage 2 (VDD3, LVDD)	V_{IN3}	-0.3	V_{DD3}+0.3	V
Operating Ambient Temperature	T_{OP}	0	70	°C
Storage Temperature	T_{STG}	-50	125	°C

Note : PVSS=LVSS=VSS=0[V]

2. Recommended Operating Conditions

Item	Symbol	Min.	Typ.	Max.	Unit
Power Supply Voltage 1 (PVDD, VDD5)	V_{DD5}	4.75	5.00	5.25	V
Power Supply Voltage 2 (VDD3, LVDD)	V_{DD3}	3.00	3.30	3.60	V
Operating Ambient Temperature	T_{OP}	0	25	70	°C

Note : PVSS=LVSS=VSS=0[V]

3. DC Characteristics

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
High Level Input Voltage 1	V_{IH1}	*1	2.2		V_{DD5} +0.5	V
Low Level Input Voltage 1	V_{IL1}	*1	-0.5		0.8	V
High Level Input Voltage 2	V_{IH2}	*2	2.2		V_{DD5} +0.5	V
Low Level Input Voltage 2	V_{IL2}	*2	-0.5		0.6	V
High Level Input Voltage 3	V_{IH3}	*3	2.2			V
Low Level Input Voltage 3	V_{IL3}	*3			0.8	V
High Level Input Voltage 4	V_{IH4}	*4	$0.7V_{DD5}$			V
Low Level Input Voltage 4	V_{IL4}	*4			$0.2V_{DD5}$	V
Input Leakage Current	I_{IL}	$0< V_{IN} < V_{DD5}$	-10		10	µA
High Level Output Voltage 1	V_{OH1}	*5, I_{OH1} = -1mA	2.4			V
Low Level Output Voltage 1	V_{OL1}	*5, I_{OL1} = 3mA			0.55	V
High Level Output Voltage 2	V_{OH2}	*6, I_{OH2} = -2mA	2.4			V
Low Level Output Voltage 2	V_{OL2}	*6, I_{OL2} = 6mA			0.55	V
High Level Output Voltage 3	V_{OH3}	*7, I_{OH3} = -4mA	2.4			V
Low Level Output Voltage 3	V_{OL3}	*7, I_{OL3} = 12mA			0.55	V
High Level Output Voltage 4	V_{OH4}	*8, I_{OH4} = -80µA	V_{DD5}-1.0			V
Low Level Output Voltage 4	V_{OL4}	*8, I_{OL4} = 2mA			0.4	V
Input Pin Capacitance	C_{IN}		5		15	pF
Clock Pin Capacitance	C_{CLK}		5		15	pF
IDSEL Pin Capacitance	C_{IDSEL}		5		15	pF
Output Leakage Current	I_{OL}		-10		10	µA
Power Supply Current 1 (Normal Operation)		PVDD+VDD5			60	mA
		VDD3			145	mA
Power Supply Current 2 (Power Save)		*9, PVDD+VDD5		0.5	2	mA
		*9, VDD3		6	10	mA

Note : Top = 0~70°C, PVDD=5.0±0.25[V], VDD5=5.0±0.25[V], VDD3=3.3±0.3[V], LVDD=3.3±0.3[V], C_L=50 pF

*1: Applicable to all PCI Iuput/Output pins and Iunput pins except PCICLK and RST# pin.

*2: Applicable to RST# pin.

*3: Applicable to CBCLK, CSDI, ACDI, ASDI, GP[7:4], RXD, VOLUP#, VOLDW#, ROMDI and TEST[7:0]# pins.

*4: Applicable to XI24 pin.

*5: Applicable to AD[31:0], C/BE[3:0]#, PAR, REQ#, PCREQ#, SERIRQ#, TXD, ALRCK, ASDO, ACDO, ACS#, ROMSK, ROMDO, ROMCS and DIT pins.

*6: Applicable to FRAME#, IRDY#, TRDY#, STOP#, DEVSEL#, PERR#, SERR#, ABCLK, ASCLK, CRST#, CSYNC and CSDO pins.

*7: Applicable to IRQ5, IRQ7, IRQ9, IRQ10, IRQ11 and INTA# pins.

*8: Applicable to CMCLK, XRST# and XO24 pins.

*9: DS-1 Power Control Register, DMC=DPLL0=DPLL1=PSN=PSL0=PSL1="1", PCICLK (33MHz) is stopped.

4. AC Characteristics

4-1. Master Clock (Fig.1)

Item	Symbol	Min.	Typ.	Max.	Unit
XI24 Cycle Time	t_{XICYC}	-	40.69	-	ns
XI24 High Time	t_{XIHIGH}	16	-	24	ns
XI24 Low Time	t_{XILOW}	16	-	24	ns

Note : Top = 0-70°C, PVDD=5.0±0.25 V, VDD5=5.0±0.25 V, VDD3=3.3±0.3 V, LVDD=3.3±0.3 V

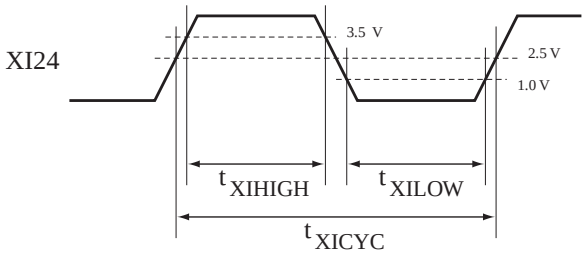


Fig.1: XI24 Master Clock timing

4-2. Reset (Fig.2)

Item	Symbol	Min.	Typ.	Max.	Unit
Reset Active Time after Power Stable	t_{RST}	1	-	-	ms
Power Stable to Reset Rising Edge	t_{RSTOFF}	10	-	-	ms
Reset Slew Rate	-	50	-	-	mV/ns

Note : Top = 0-70°C, PVDD=5.0±0.25 V, VDD5=5.0±0.25 V, VDD3=3.3±0.3 V, LVDD=3.3±0.3 V, C_L=50 pF

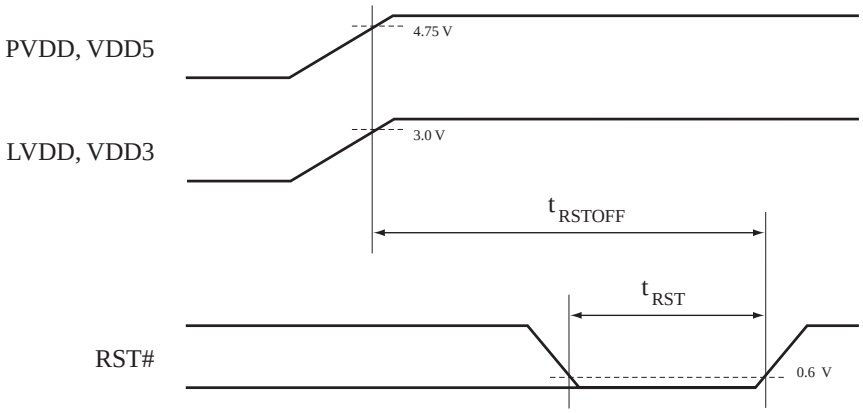


Fig.2: PCI Reset timing

4-3. PCI Interface (Fig.3, 4)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
PCICLK Cycle Time	t_{PCYC}		30	-	-	ns
PCICLK High Time	t_{PHIGH}		11	-	-	ns
PCICLK Low Time	t_{PLOW}		11	-	-	ns
PCICLK Slew Rate	-		1	-	4	V/ns
PCICLK to Signal Valid Delay	t_{PVAL}	(Bused signal)	2	-	11	ns
	$t_{PVAL(PTP)}$	(Point to Point)	2	-	12	ns
Float to Active Delay	t_{PON}		2	-	-	ns
Active to Float Delay	t_{POFF}		-	-	28	ns
Input Setup Time to PCICLK	t_{PSU}	(Bused signal)	7	-	-	ns
	$t_{PSU(PTP)}$	*10 (Point to Point)	10			ns
		*11 (Point to Point)	12	-	-	ns
Input Hold Time for PCICLK	t_{PH}		0	-	-	ns

Note : Top = 0-70°C, PVDD=5.0±0.25 V, VDD5=5.0±0.25 V, VDD3=3.3±0.3 V, LVDD=3.3±0.3 V, C_L=50 pF

*10: This characteristic is applicable to REQ# and PCREQ# signal.

*11: This characteristic is applicable to GNT# and PCGNT# signal.

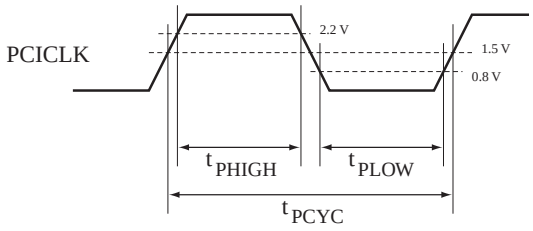


Fig.3: PCI Clock timing

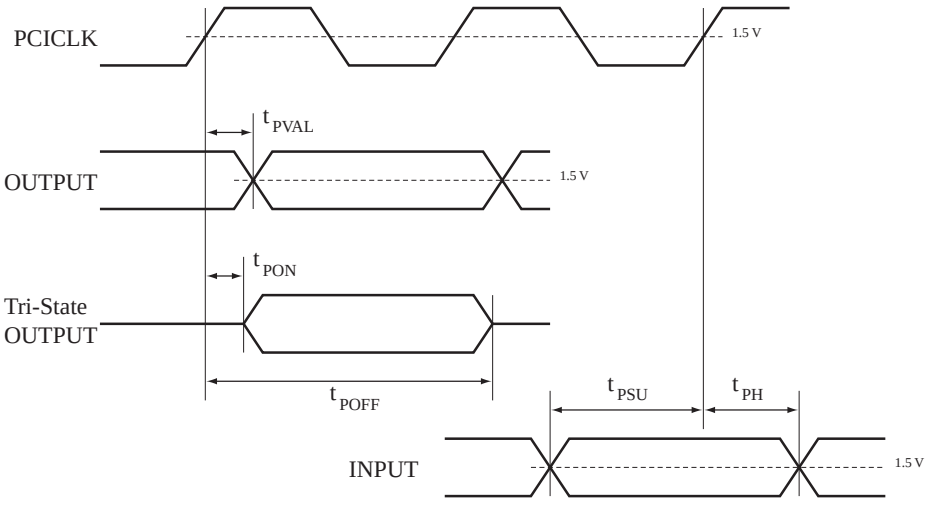


Fig.4: PCI Bus Signals timing

4-4. AC'97 / AC3F2 Master Clock (Fig.5)

Item	Symbol	Min.	Typ.	Max.	Unit
CMCLK Cycle Time	t_{CMCYC}	-	40.69	-	ns
CMCLK High Time	t_{CMHIGH}	8	-	-	ns
CMCLK Low Time	t_{CMLOW}	8		-	ns
CMCLK Rising Time	t_{CMR}	-	4.6	-	ns
CMCLK Falling Time	t_{CMF}	-	2.1	-	ns

Note : Top = 0-70°C, PVDD=5.0±0.25 V, VDD5=5.0±0.25 V, VDD3=3.3±0.3 V, LVDD=3.3±0.3 V, C_L=50 pF

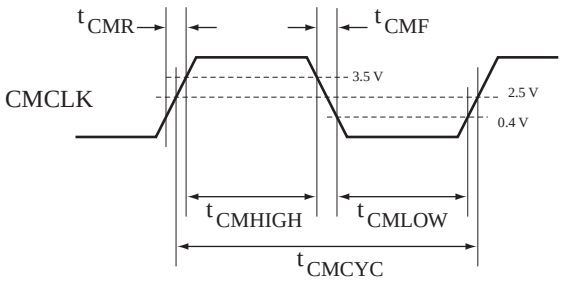


Fig.5: Master Clock timing for AC'97 and AC3F2

4-5. AC-link (Fig.6)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
CBCLK Cycle Time	t_{CBICYC}		-	81.4	-	ns
CBCLK High Time	$t_{CBIHIGH}$		35	40.7	45	ns
CBCLK Low Time	t_{CBILOW}		35	40.7	45	ns
CSYNC Cycle Time	t_{CSYCYC}		-	20.8	-	ns
CSYNC High Time	$t_{CSYHIGH}$		-	1.3	-	ns
CSYNC Low Time	t_{CSYLOW}		-	19.5	-	ns
CBCLK to Signal Valid Delay	t_{CVAL}	*12	-	-	20	ns
Output Hold Time for CBCLK	t_{COH}	*12	0	-	-	ns
Input Setup Time to CBCLK	t_{CISU}	*13	15	-	-	ns
Input Hold Time for CBCLK	t_{CIH}	*13	5	-	-	ns
Warm Reset Width			-	1.3	-	µs

Note) Top = 0-70°C, PVDD=5.0±0.25 V, VDD5=5.0±0.25 V, VDD3=3.3±0.3 V, LVDD=3.3±0.3 V, C_L=50 pF

*12: This characteristic is applicable to CSYNC and CSDO signal.

*13: This characteristic is applicable to CSDI signal.

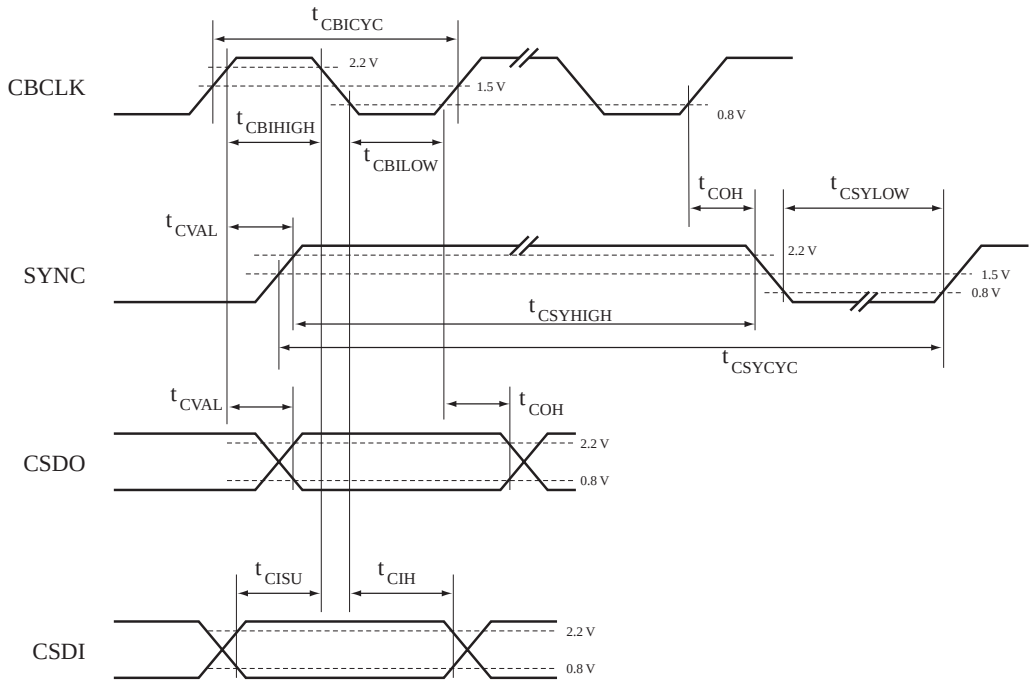


Fig.6: AC-link timing

4-6 AC3F2 Interface (Fig.7, 8)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
ASCLK Cycle Time	t_{ASCCYC}		-	325	-	ns
ASCLK High Time	$t_{ASCHIGH}$		140	-	180	ns
ASCLK Low Time	t_{ASCLOW}		140	-	180	ns
ASCLK to Signal Valid Delay	t_{ACVAL}	*14	-	-	50	ns
Output Hold Time for ASCLK	t_{ACOH}	*14	-10	-	-	ns
Input Setup Time to ASCLK	t_{ACISU}	*15	20	-	-	ns
Input Hold Time for ASCLK	t_{ACIH}	*15	10	-	-	ns
ABCLK Cycle Time	t_{ABICYC}		-	325	-	ns
ABCLK High Time	$t_{ABIHIGH}$		140	-	180	ns
ABCLK Low Time	t_{ABILOW}		140	-	180	ns
ABCLK to Signal Valid Delay	t_{ASVAL}	*16	-	-	50	ns
Output Hold Time for ABCLK	t_{ASOH}	*16	-10	-	-	ns
Input Setup Time to ABCLK	t_{ASISU}	*17	20	-	-	ns
Input Hold Time for ABCLK	t_{ASIH}	*17	10	-	-	ns

Note) Top = 0-70°C, PVDD=5.0±0.25 V, VDD5=5.0±0.25 V, VDD3=3.3±0.3 V, LVDD=3.3±0.3 V, C_L=50 pF

*14: This characteristic is applicable to ACS and ACDO signal.

*15:This characteristic is applicable to ACDI signal.

*16: This characteristic is applicable to ASDO and ALRCK signal.

*17: This characteristic is applicable to ASDI signal.

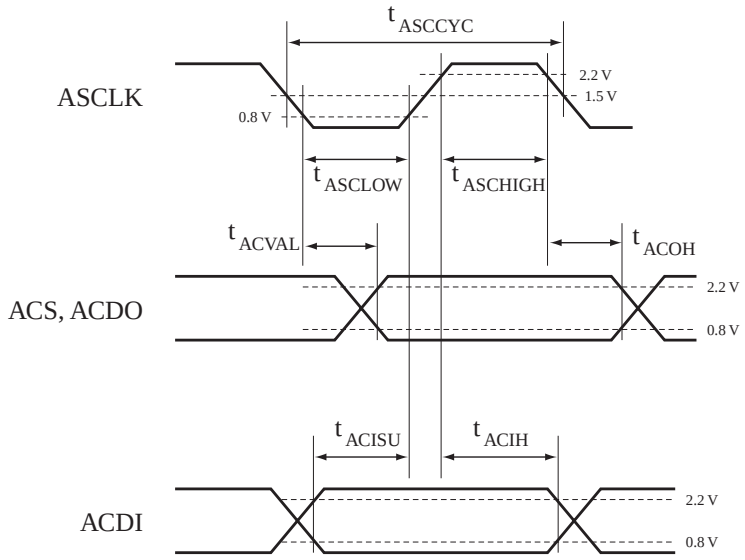


Fig.7: AC3F2 Control Interface timing

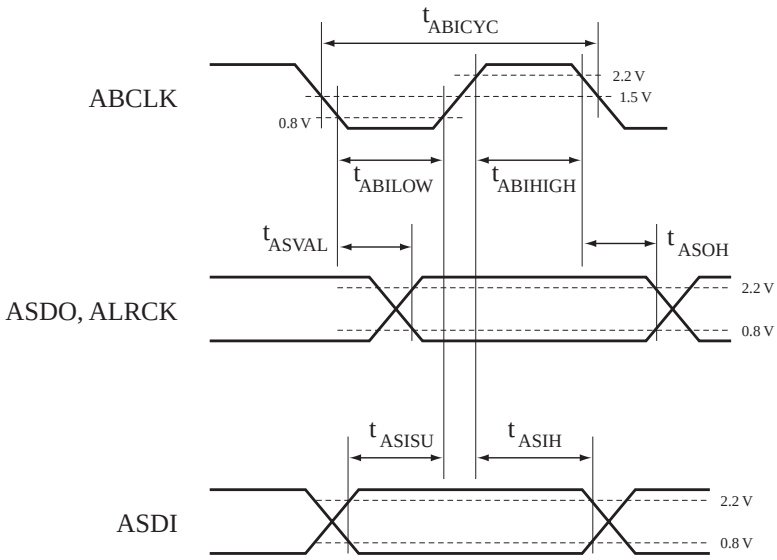
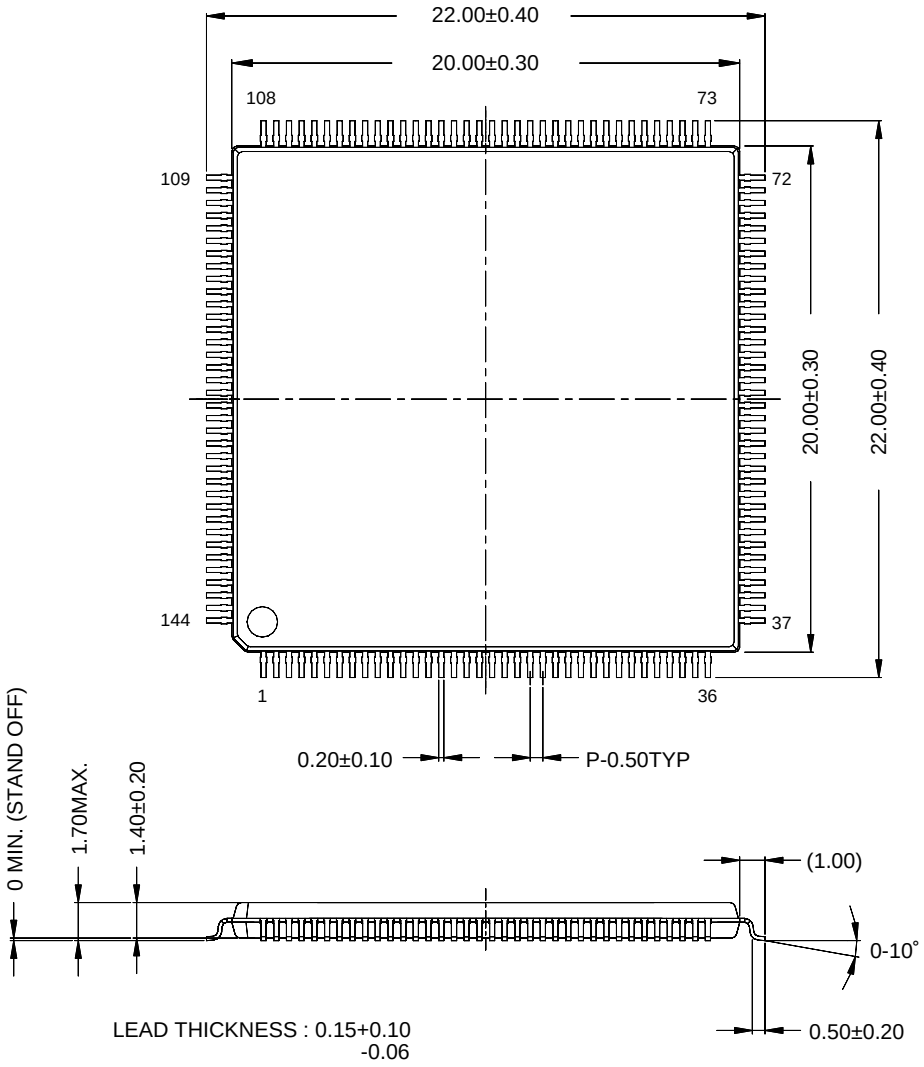


Fig.8: AC3F2 Audio Interface timing

■ EXTERNAL DIMENSIONS

YMF724F-V



The shape of the molded corner may slightly different from the shape in this diagram.

The figure in the parenthesis ( ) should be used as a reference.

Plastic body dimensions do not include burr of resin.

UNIT : mm

Note : The LSIs for surface mount need especial consideration on storage and soldering conditions.
For detailed information, please contact your nearest agent of Yamaha.

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