chapter 7

AUDIO SUBSYSTEM

Functional Description

The entertainment audio subsystem provides 16-bit stereo audio support for CD-Audio, Zoomed Video (ZV), Moving Picture Experts Group (MPEG)/TV, and entertainment software compatible with industry standards. The ES1869 AudioDrive component possesses an embedded microcontroller, OPL3™ superset ESFM™ music synthesizer, 16-bit stereo wave analog-to-digital converter (ADC) and digital-to-analog converter (DAC), 16-bit stereo music DAC, MPU-401 UART serial port, dual game port, full Plug and Play (PnP) support, hardware master volume control, FS Zoom Video (ZV) interface, DMA control logic with first in, first out (FIFO), and ISA bus interface logic. The audio subsystem can capture and play back .WAV files.

By itself, the unit is capable of mono sound through a single speaker. When attached to the Mobile 3500 Expansion Unit (M35EU), full stereo capabilities are available through two acoustically enhanced speakers and a subwoofer.

All audio, including CPU-generated tones, keyboard beeps, audio from PC Card and MPEG/ZV options, and audio from sound files, is played through the internal speakers, or, if connected, headphones or external speakers. A programmable volume control sets the audio output from the ES1869 to a selected value. A 1.5 W stereo amplifier and equalizer circuit provides the power necessary to drive the line devices, speakers, or earphones.

A block diagram of the audio subsystem is shown in Figure 7-1.

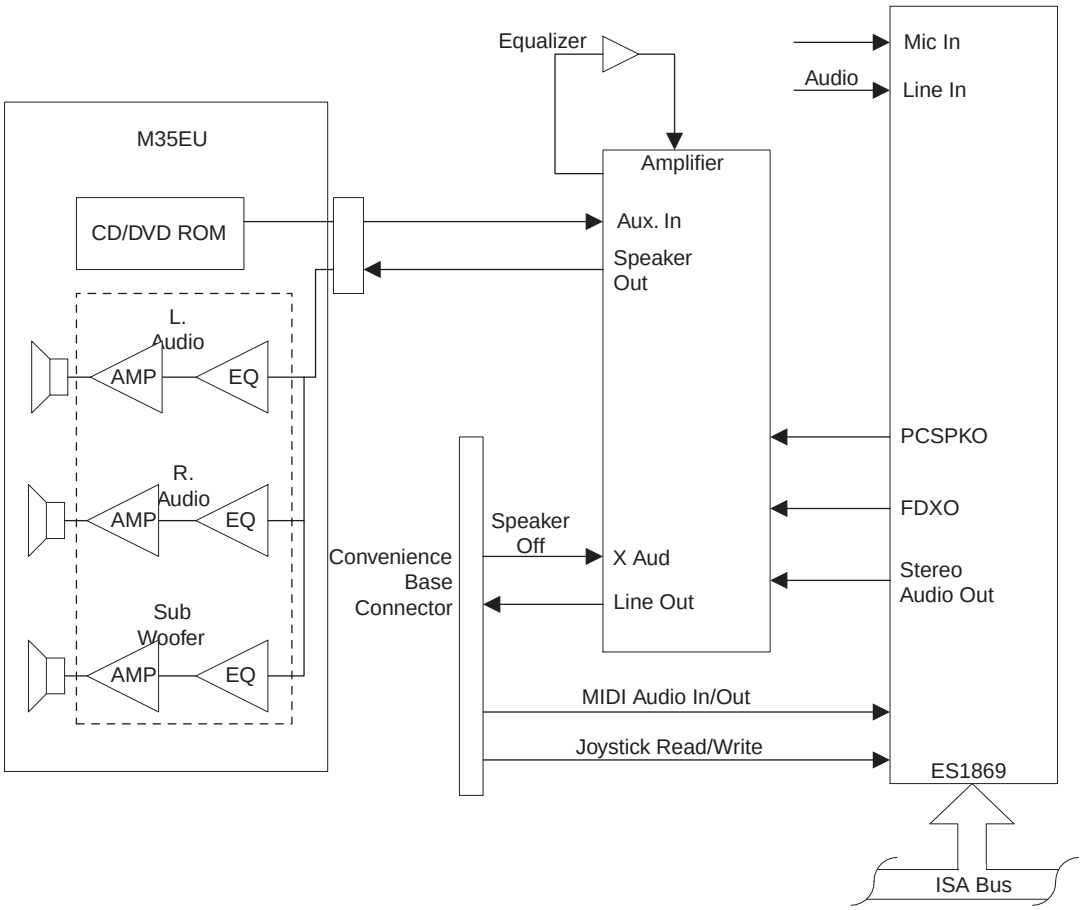

Figure 7-1. *Audio Subsystem, Block Diagram*

Features provided by the ES1869 audio controller are as follows:

- Plug and play support using internal ROM
- Stereo full duplex through two DMA channels
- Self-timed joystick port
- I2S serial bus to Zoom Video Port
- General interrupt mapping and shared interrupts

The TPA0102 audio interface and equalization circuitry are physically located on the audio daughter card along with some supporting logic. The ES1869 audio controller resides on the an audio only board that connects to the system board through the sub-ISA connector. Audio information from the CD-ROM and PC Card subsystems is sent to the audio controller through the ISA connector.

Standard Audio I/O

The following paragraphs describe the external audio input and output connections of the audio subsystem.

Mic In (Input): The mic-in connector is a two-conductor mini-jack (3.5-mm) designed to work only with a mono electret microphone. Plugging into the mic-in jack disconnects the internal microphone from the audio subsystem.

Headphone Out/Line Out (Output): The headphone-out connector is a three-conductor (stereo) mini-jack primarily designed to allow connection of a pair of headphones. This port can also be used to connect a pair of "powered" speakers (e.g., the type meant to be used with portable radio/cassette players). Plugging into the headphone-out jack disconnects the internal speakers from the audio subsystem.

Audio I/O

The convenience base duplicates the following audio interfaces for external components:

- **Line Out (Output):** This three-conductor mini-jack allows connection to a pair of powered speakers.
- **Line In (Input):** This three-connector mini-jack accepts line-level outputs.
- **Joystick/MIDI Port:** This interface is used for connecting either a joystick or MIDI component.

Pulse Code Operation

The ES1869 includes analog-to-digital converters (ADC) and digital-to-analog converters (DAC) that use pulse code modulation (PCM) to capture and play back waveform (.WAV) data files. The .WAV files produced through PCM contain numerical values that represent waveform amplitudes that, measured by timed sampling, determine the frequencies. This section describes ADC and DAC operation as well as how the digital audio data is transferred over the peripheral bus.

Analog-To-Digital Converter Operation

The ADC receives an analog signal and quantizes it into a digital code that specifies the voltage level of the analog signal at that particular time. Depending on the mode of operation, up to eight formats are available from the following options:

- Mono or stereo
- 8- or 16-bit
- Signed or unsigned

Digital-To Analog Converter Operation

The DAC conversion simply reverses the procedure of the ADC. The digital audio data stream is received by the DAC, and the quantized values are decoded at the sampling frequency rate. A filter provides the final shaping of the wave before it is applied to the analog output circuitry.

DAC/ADC Configuration

The DAC/ADC used for PCM operation can be configured for compatible (common sound board functionality) mode or set up for extended mode, which has performance advantages over compatible mode. Table 7-1 lists the differences between compatible and extended modes.

Table 7-1
Mode Differences

Function	Compatibility Mode	Extended Mode
FIFO Size Available	64 bytes (SW Cntl)	256 bytes (HW Cntl)
Mono 8-bit ADC, DAC	44 kHz Maximum Sampling	48 kHz Maximum Sampling
Mono 16-bit ADC, DAC	22 kHz Maximum Sampling	48 kHz Maximum Sampling
Stereo 8-bit ADC, DAC	22 kHz Maximum Sampling	48 kHz Maximum Sampling
Stereo 16-bit ADC	11 kHz Maximum Sampling	48 kHz Maximum Sampling
Stereo 16-bit DAC	11 kHz Maximum Sampling	48 kHz Maximum Sampling
Signed/Unsigned Control	No	Yes
AGC During Capture	Mono Only (22 kHz)	No
Programmed I/O Block Transfer	No	Yes
FIFO Status Flags	No	Yes
Auto Reload DMA	Yes	Yes
Time Base for Programmable Timer	1 MHz or 1.5 MHz	800 kHz or 400 kHz
ADC/DAC Jitter	+/- 2 μsec	None

The quality of audio is largely determined by two factors: resolution and sampling rate. A 16-bit resolution provides more levels of amplitude for definition as opposed to 8 bits. A higher sampling rate provides more accurate digital representation of the audio signal. The rule of thumb (based on the Nyquist theorem) dictates that the sampling rate should be at least twice the highest frequency to be processed. For example, if 20 kHz is anticipated, then the sampling rate should be set to 40K per second or greater.

Depending on the mode used, the sampling rate can be constrained by the resolution selected as indicated in the table above. Additionally, higher resolutions and sampling rates require more storage space for a given period of audio recording. Recording audio using 16-bit stereo resolution at a 44-kHz sampling rate takes up approximately 175 KB of hard drive space per second.

PCM Bus Cycles

The I/O and DMA cycles used by PCM (pulse code modulation) operations to process. WAV data follow standard ISA bus conventions. All bus transfers occur at the byte level. Programmed I/O cycles are always used for programming the control registers and may also be used for transferring audio data to and from the ES1869 as well. The use of DMA cycles allows the use of discrete transfers for each byte of audio data to and from the ES1869.

The audio subsystem can be configured for either single DMA channel mode or dual DMA channel mode. Single DMA channel mode means that capture and playback operations share the same (playback) DMA channel and only one operation, capture or playback, is possible at a time. Dual DMA channel mode allows simultaneous capture/playback operation to occur if desired, but requires two dedicated DMA channels. It is the programmer's responsibility to ensure that the capture and playback data have the same sample rate and format.

For transferring audio data over the bus, the ES1869 builds the quantized audio data using the "little endian" format. This format is defined as having the least significant byte of a multibyte word occupying the lowest memory address. Stereo capture and playback alternate between the left and right channels, starting with the left channel first. Mono capture samples only the left channel input, while mono playback routes the left channel through both left and right output circuitry.

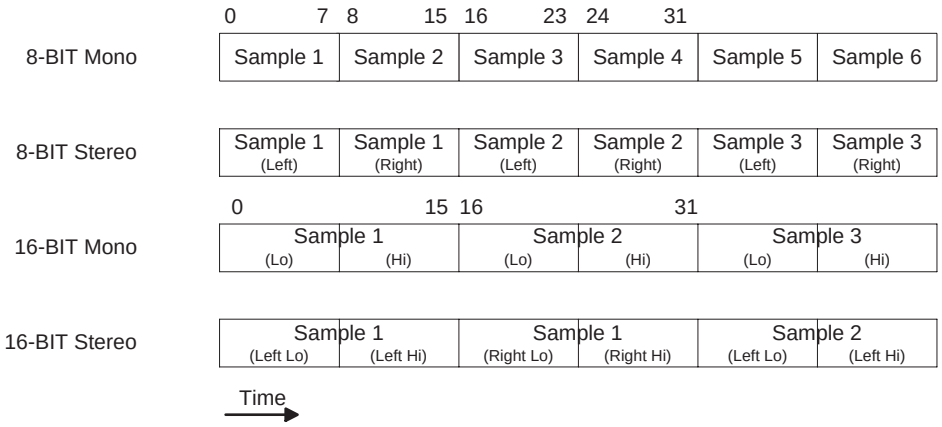

Figure 7-2. *ES1869 to ISA Bus Audio Formats*

FM Synthesis

The ES1869 component includes FM synthesis logic that supports the playback of MIDI (.MID) data files. The FM synthesizer function is register-controlled and uses frequency modulation to generate harmonics that will simulate the tone of musical instruments.

MIDI (.MID) files do not contain audio information in the same way that .WAV files do. In .MID files, audio data consists of note on/note off, tone type, and amplitude information. Audio stored in the .MID file format has the benefit of taking up far less storage space than audio stored as .WAV files[1].

A number of parameters affecting the generated sound are selectable or programmable. These parameters including the following:

- Waveform shape
- Waveform envelope characteristics (attack rate, decay rate, sustain level, release level)
- Key scale rate
- Rhythm percussion sounds

FM Synthesis Cycles

The ES1869 component provides full FM synthesis support for playback of .MID data files. Processing .MID files is handled primarily with write cycles to the ES1869. A read cycle is used only for reading status. Note that if the succeeding data byte is meant for the same location as the previous data byte, then the address does not need to be rewritten.

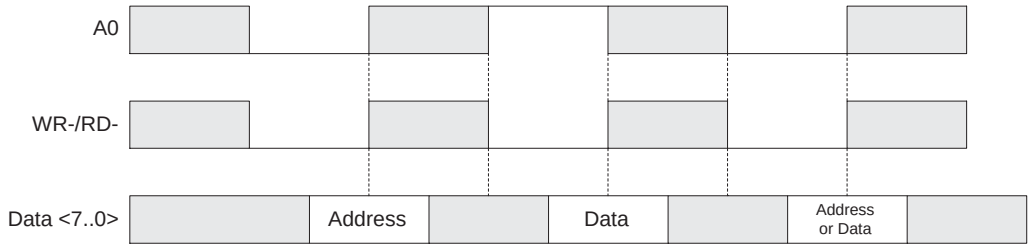

Figure 7-3. *FM Synthesis Cycle*

[1]The Joystick/MIDI interface of the optional expansion unit allows the connection of MIDI equipment to the system, enabling the transfer of digital MIDI data between the system and MIDI equipment.

Table 7-2 describes the available MIDI instrument sounds available.

Table 7-2
General MIDI Melodic Instrument Map

Patch #Instrument	Patch #Instrument	Patch #Instrument	Patch #Instrument
1 Acoustic Grand Piano	33 Acoustic Bass	65 Soprano Sax	97 Rain
2 Bright Acoustic Grand Piano	34 E. Bass - Finger	66 Alto Sax	98 Sound track
3 Electric Piano	35 E. Bass - Pick	67 Tenor Sax	99 Crystal
4 Honky-Tonk Piano	36 Fretless Bass	68 Baritone Sax	100 Atmosphere
5 Electric Piano 1	37 Slap Bass 1	69 Oboe	101 Brightness
6 Electric Piano 2	38 Slap Bass 2	70 English Horn	102 Goblins
7 Harpsichord	39 Synthesized Bass 1	71 Bassoon	103 Echoes
8 Clarinet	40 Synthesized Bass 2	72 Clarinet	104 Sci Fi
9 Celestra	41 Violin	73 Piccolo	105 Sitar
10 Glockenspiel	42 Viola	74 Flute	106 Banjo
11 Music Box	43 Cello	75 Recorder	107 Shamisen
12 Vibraphone	44 Contrabass	76 Pan Flute	108 Koto
13 Marimba	45 Tremelo Strings	77 Blown Bottle	109 Kalimba
14 Xylophone	46 Pizzicato Strings	78 Shakuhachi	110 Bag Pipe
15 Tubular Bells	47 Orchestral Harp	79 Whistle	111 Fiddle
16 Dulcimer	48 Timpani	80 Ocarina	112 Shanai
17 Drawbar Organ	49 String Ensemble 1	81 Lead 1 - Square	113 Tinker Bell
18 Percussive Organ	50 String Ensemble 2	82 Lead 2 - Sawtooth	114 Agogo
19 Rock Organ	51 Synthesized Strings 1	83 Lead 3 - Calliope	115 Steel Drums
20 Church Organ	52 Synthesized Strings 2	84 Lead 4 - Chiff	116 Woodblock
21 Reed Organ	53 Choir Aahs	85 Lead 5 - Charang	117 Taiko Drum
22 Accordion	54 Voice Oohs	86 Lead 6 - Voice	118 Melodic Tom
23 Harmonica	55 Synthesized Voice	87 Lead 7 - Fifth	119 Synthesized Drum
24 Tango Accordion	56 Orchestra Hit	88 Bass + Lead	120 Reverse Cymbal
25 Acoustic Guitar - Nylon	57 Trumpet	89 Pad 1 - New Age	121 Guitar Fret Noise
26 Acoustic Guitar - Steel	58 Trombone	90 Pad 2 - Warm	122 Breath Noise
27 Electric Guitar - Jazz	59 Tuba	91 Pad 3 - Polysynth	123 Seashore
28 Electric Guitar - Clean	60 Muted Trumpet	92 Pad 4 - Choir	124 Bird Tweet
29 Electric Guitar - Muted	61 French Horn	93 Pad 5 - Bowed	125 Telephone Ring
30 Overdriven Guitar	62 Brass Section	94 Pad 6 - Metallic	126 Helicopter
31 Distortion Guitar	63 Synthesized Bass 1	95 Pad 7 - Halo	127 Applause
32 Guitar Harmonics	64 Synthesized Bass 2	96 Pad 8 - Sweep	128 Gunshot

Table 7-3 lists the percussive options available.

Table 7-3.
General MIDI Percussion Instrument Map

Note #Instrument	Patch #Instrument	Patch #Instrument	Patch #Instrument
35 Acoustic Bass Drum	47 Low Mid Tom	59 High Timbale	71 Short Whistle
36 Bass Drum 1	48 High Mid Tom	60 Low Timbale	72 Long Whistle
37 Side Stick	49 Crash Cymbal 1	61 Low Bongo	73 Short Guiro
38 Acoustic Snare	50 High Tom	62 Mute Hi Conga	74 Long Guiro
39 Hand Clap	51 Ride Cymbal	63 Open Hi Conga	75 Claves
40 Electric Snare	52 Chinese Cymbal	64 Low Conga	76 High Wood Block
41 Low Floor Tom	53 Ride Bell	65 High Timbale	77 Low Wood Block
42 Closed Hi Hat	54 Tambourine	66 Low Timbale	78 Mute Cuica
43 High Floor Tom	55 Splash Cymbal	67 High Agogo	79 Open Cuica
44 Pedal Hi Hat	56 Cowbell	68 Low Agogo	80 Mute Triangle
45 Low Tom	57 Crash Cymbal 2	69 Cabasa	81 Open Triangle
46 Open Hi Hat	58 Vibraslap	70 Maracas	

MIDI Keyboard Control

When the computer is docked in the convenience base , a MIDI keyboard can be attached to the joystick/MIDI connector on the convenience base and used to control wavetable synthesis. For this configuration, the MPU-401 interface of the ES1869 should be configured in the Smart mode (instead of the UART mode).

NOTE: A MIDI keyboard left connected to the system may cause problems if FM synthesis is used simultaneously.

Register Programming

The audio subsystem can be made inactive using various methods, depending on whether the intent is toward power management or freeing up system resources. The system ROM includes firmware support for the audio subsystem.

The audio subsystem is controlled through I/O mapped registers. These registers are classified as either for joystick/PCM control or for FM synthesis control.

Table 7-4
ES1869 Registers

Address [1]	Register	R/W
0201h	Joystick Control	R/W
02*n*0h-02*n*Fh	PCM Processor	R/W
0388h-038Bh	FM Synthesizer	R/W

NOTE: [1] *n* = 2 for primary address (default), = 4 for secondary.

PCM Registers

The joystick/PCM functions are controlled through the I/O locations listed in Table 7-5.

The system allows reconfiguration to a secondary, tertiary, or quaternary base address as follows:

- Unlock address configuration register with a write (any value) to port FBh.
- Write 00h to port E0h.
- Write desired value of base address to bits <1,0> of port E1h.
- Lock the configuration with a write (any value) to port F9h.

Address Configuration Register, E1h

BIT	FUNCTION
7..3	Reserved - read/write 0s.
2	Chip Enable: 0 = Audio disabled 1 = Audio enabled
1,0	PCM Ops Base Address Select 00 = 220h 01 = 230h 10 = 240h 11 = 250h

Table 7-5
Joystick/PCM Registers

Address [1]	Register	R/W
0201h	Joystick Control	R/W
02n0h-02n3h	FM Synthesizer	R/W
02n4h	Mixer Address	R/W
02n5h	Mixer Data	R/W
02n6h	Reset Control (Write), Activity/Power Status (Read)	R/W
02n7h	Power Management	R/W
02n8h-02n9h	Reserved	R/W
02nAh	Read Buffer Input Data	RO
02nBh	Reserved	R/W
02nCh	Command/Data (Write), Status (Read)	R/W
02^{nD}h	Reserved	R/W
02nEh	Data Available Status	RO
02nFh	FIFO I/O Address (Extended Mode)	R/W

NOTE: [1] n = 2 for primary address (default), = 4 for secondary.

The following pages include descriptions of joystick/PCM registers. For detailed programming information on the ES1869, refer to the *ES1869 AudioDrive Design Guide* by ESS Technology, Inc.

Joystick I/O Register (0201h, Read/Write)

This 8-bit register is used for reading data from or writing data to the joystick interface. An access generates the appropriate (read or write) control signal from the ES1869.

FM Synthesis Control Registers (02n0h-02n3h, Read/Write)

The ES1869 decodes addresses in this range only to generate a chip enable signal to the YMF262. Register descriptions for these locations are described later in the "FM Synthesis Control Registers" section.

Mixer Registers (02n4h, 02n5h, Read/Write)

The mixer registers allow level control of the audio inputs to the ES1869. Recording source and stereo/mono mode are also selected through these registers. Two sets of indexed registers are available: one set (00h-2Eh) is compatible with common sound cards, while the other set (00h-3Eh) provides extended capabilities. Both sets are accessed through two locations, 02n4h and 02n5h. The index is written to 02n4h and the data is written to or read from 02n5h.

02n4h, Mixer Index

BIT	FUNCTION
7,6	Reserved.
5..1	Index Address (refer to Table 7-4).
0	MXD - Mixer Flag. When set, indicates mixer register has been written to but not processed.

02n5h, Mixer Data

BIT	FUNCTION
7..0	Data

Table 7-6
Mixer Functions

Compatible Index	Extended Index	Function	Reset Value
00h	00h	Mixer Reset	—
04h	14h	Voice Volume	88h
0Ah	1Ah	Microphone Volume	00h
0Ch	1Ch	ADC (Recording) Source	00h
0Eh	1Eh	Stereo/Mono Switch	00h
22h	32h	Master Volume	88h
26h	36h	FM Volume	88h
28h	38h	CD Volume	00h
2Eh	3Eh	Line Volume	00h

The mixer functions have the same mapping for compatible and extended modes. In compatible mode, level control is confined to a 3-bit resolution per channel (Mic mix has 2 bits). In extended mode, a 4-bit resolution is used.

Mixer Reset Register (Index 00h, Write Only)

This register is used to reset the mixer values (a software reset does not affect the mixer registers). A write of any value to this register resets the mixer registers to their initial values.

Voice Level Register (Index 04h or 14h, Read/Write)

This register sets the level of volume for the voice audio.

Index 04h, Compatible, R/W

BIT	FUNCTION
7..5	Voice Volume Left
4	Reserved
3..1	Voice Volume Right
0	Reserved

Index 14h, Extended, R/W

BIT	FUNCTION
7..4	Voice Volume Left
3..0	Voice Volume Right

Microphone Level Register (Index 0Ah or 1Ah, Read/Write)

This register sets the level of volume for the microphone audio.

Index 0Ah, Compatible, R/W

BIT	FUNCTION
7..3	Reserved
2,1	Mic Volume
0	Reserved

Index 1Ah, Extended, R/W

BIT	FUNCTION
7..4	Mic Volume Left
3..0	Mic Volume Right

ADC (Recording Source) Register (Index 0Ch or 1Ch, Read/Write)

This register selects the input sound source for processing by the ADC.

Index 0Ch, Compatible, R/W

BIT	FUNCTION
7..3	Reserved
2,1	ADC Source: 00 = Microphone (default) 01 = CD 10 = Microphone 11 = Line
0	Reserved

Index 1Ch, Extended, R/W

BIT	FUNCTION
7..3	Reserved.
2..0	ADC Source : 000 = Mic 001 = L - mic R - master volume l & 010 = R 011 = CD 100 = Aout 101 = Mic 110 = Record mixer 111 = Line input Master volume input
0	Reserved.

NOTE: Some sound adapters use bit <5..3> of this register for filter control. On the ES1869, this bit has no effect.

Stereo/Mono Switch Register (Index 0Eh or 1Eh, Read/Write)

Bit <1> of this register, when set, selects the stereo mode for the DAC. This function is valid only for DMA transfers in compatible mode. The default/reset state of bit <1> is zero.

NOTE: Some sound adapters use bit <5> of this register for filter control. On the ES1869, this bit has no effect.

Master Level Register (Index 22h or 32h, Read/Write)

This register sets the master volume level.

Index 22h, Compatible, R/W

BIT	FUNCTION
7..5	Master Volume Left
4	Reserved
3..1	Master Volume Right
0	Reserved

Index 32h, Extended, R/W

BIT	FUNCTION
7..4	Master Volume Left
3..0	Master Volume Right

FM Level Register (Index 26h or 36h, Read/Write)

This register sets the volume level of the FM synthesis input.

Index 26h, Compatible, R/W

BIT	FUNCTION
7..5	FM Volume Left
4	Reserved
3..1	FM Volume Right
0	Reserved

Index 36h, Extended, R/W

BIT	FUNCTION
7..4	FM Volume Left
3..0	FM Volume Right

CD Level Register (Index 28h or 38h, Read/Write)

This register sets the volume level of the CD-ROM input.

Index 28h, Compatible, R/W

BIT	FUNCTION
7..5	CD Volume Left
4	Reserved
3..1	CD Volume Right
0	Reserved

Index 38h, Extended, R/W

BIT	FUNCTION
7..4	CD Volume Left
3..0	CD Volume Right

Line Level Register (Index 2Eh or 3Eh, Read/Write)

This register sets the volume level of the line audio input.

Index 2Eh, Compatible, R/W

BIT	FUNCTION
7..5	Line Volume Left
4	Reserved
3..1	Line Volume Right
0	Reserved

Index 3Eh, Extended, R/W

BIT	FUNCTION
7..4	Line Volume Left
3..0	Line Volume Right

Reset/Power Management Register (02n6h, Read/Write)

This register, on a write, controls the reset state of the ES1869 and, on a read, reports activity flags and power management status.

02n6h, Read/Write

BIT	FUNCTION
7	Activity Flag 2 (RO). When read as 0, indicates read or write has occurred to an FM port (02x0h-02x3h, 02x8h, 02x9h, 0388h-03Bh)
6	Activity Flag 1 (RO). When read as 0, indicates a read has occurred to ports 02xCh and/or 02xEh.
5	Activity Flag 0 (RO). When read as 0, indicates one or more of the following actions have occurred: DMA read/write to 02n4h, 02n5h DMA write to 02n6h DMA read of 02nAh DMA write to 02nCh DMA read/write to 02nFh
4	Reserved.
3	Power Down Status (RO). When read as 0, the digital section of the **ES1869** is powered down.
2	MIDI Mode (RO). When read as 0, a MIDI command (30h, 34h, or 35h) is being processed.
1	FIFO Reset (R/W) Compatibility Mode: Don't care Extended Mode: 0 = Release FIFO from reset. 1 = Hold FIFO in reset.
0	Software Reset (R/W): 0 = Release **ES1869** from reset. 1 = Hold **ES1869** in reset.

Power Management Register (02n7h Read/Write)

This register controls power management functions of the ES1869.

02n7h, Read/Write

BIT	FUNCTION
7,6	Reserved - read 0s
5	FM Reset. When cleared (0), forces reset to the FM logic.
4	FM Wakeup Control. 0 = Wakeup on FM activity is disabled 1 = Wakeup on FM activity is enabled
3,2	Power Down Control. 00 = **ES1869** full on 01 = Complete power down (analog and digital) 11 = Partial power down (digital down, analog up)
1	GPO1 - Not used
0	GPO0 - Used to control the power amp of the system unit internal speakers. 0 = Amp power ON 1 = Amp power OFF

Read Buffer Register (02nAh, Read Only)

This 8-bit register holds the input data from the read buffer. Bit <7> of 02nEh can be checked to determine if contents are valid.

ES1869 Status Register (02nCh, Read)

This 8-bit register is read to determine the overall status of the ES1869. This register should be checked (read) before sending (writing) a command or data to 02nCh.

02xCh, Read

BIT	FUNCTION
7	Write Buffer Status: 0 = Buffer available (not busy) 1 = Buffer not available (busy)
6	Read Buffer Status: 0 = Data not available 1 = Data available
5	FIFO Full: When set, indicates 256 bytes loaded.
4	FIFO Empty: When set, indicates 0 bytes loaded.
3	FIFO Half Empty: Set during extended mode.
2	Processor IRQ Flag. when set, **ES1869** internal processor generated an IRQ.
1	FIFO IRQ Flag. When set, indicates change in bit <3>, resulting in an IRQ. Used by programmed I/O with FIFO in extended mode.
0	DMA Counter Overflow IRQ Flag. When set, indicates DMA counter overflow resulting in an IRQ.

Command/Data Register (02nCh, Write)

This 8-bit register is used for writing commands or data to the ES1869. Before a write, this location should be read first to determine buffer/FIFO status (refer to the read bit definitions previously described). Table 7-7 lists and describes the commands available.

Table 7-7
ESS 1869 Commands

Command	Function	Mode
10h	Direct write 8-bit DAC in 8-bit signed format.	Comp.
11h	Direct write 16-bit DAC in 16-bit unsigned format.	Ext.
14h	Start 8-bit DAC transfer in normal mode DMA.	Comp.
15h	Start 16-bit DAC transfer in normal mode DMA.	Ext.
1Ch	Start 8-bit DAC transfer in auto-init. mode DMA.	Comp.
1Dh	Start 16-bit DAC transfer in auto-init. mode DMA.	Ext.
20h	Direct mode 8-bit ADC in 8-bit unsigned format.	Comp.
21h	Direct mode 16-bit ADC in 16-bit unsigned format.	Ext.
24h	Start 8-bit ADC transfer in normal mode DMA.	Comp.
25h	Start 16-bit ADC transfer in normal mode DMA.	Ext.
2Ch	Start 8-bit ADC transfer in auto-init. mode DMA.	Comp.
2Dh	Start 16-bit ADC transfer in auto-init mode DMA.	Ext.
30h, 31h	MIDI input mode. Value 31h will cause IRQ for each MIDI byte.	Comp.
34h, 35h	MIDI output mode. Value 35h will cause IRQ for each MIDI byte.	Comp.
38h	MIDI output single byte.	Comp.
40h	Set time constant for timer used for DMA with DAC/ADC.	Comp.
41h	Alternate time constant.	Ext.
42h	Independent setting of filter clock.	Ext.
48h	Block size.	Comp.
64h	Start DMA to DAC in ESPCM low compression format.	Ext.
65h	Same as above but with reference byte flag.	Ext.
66h	Start DMA to DAC in ESPCM medium compression format.	Ext.
67h	Same as above but with reference byte flag.	Ext.
6Ah	Start DMA to DAC in ESPCM high compression format.	Ext.
6Bh	Same as above but with reference byte flag.	Ext.
6Eh	Start DMA to ADC in ESPCM low compression format.	Ext.
6Fh	Same as above but with reference byte flag.	Ext.
74h	Start DMA to DAC in ADPCM 4-bit format.	Comp.
75h	Same as above but with reference flag.	Comp.
76h	Start DMA to DAC in ADPCM 2.6-bit format.	Comp.
77h	Same as above but with reference flag.	Comp.
7Ah	Start DMA to DAC in ADPCM 2.6-bit format.	Comp.
7Bh	Same as above but with reference flag.	Comp.
80h	Insert Silence period.	Comp.
90h	Start DMA to DAC in auto-init. format.	Comp.
91h	Start DMA 8-bit transfer to DAC.	Comp.
98h	Start high-speed 8-bit DMA from ADC in auto-init mode.	Comp.

Continued

Table 7-7 ESS 1869 Commands *Continued*

Command	Function	Mode
99h	Start high-speed 8-bit DMA from ADC.	Comp.
Axh, Bxh, Cxh	ES1869 Extension Commands.	Ext.
C0h	Enables Reads of ES1869 registers used for Extended Mode: Axh, Bxh.	Ext.
C1h	Resume after Suspend.	Ext.
C6h	Extension command enable (for Axh, Bxh).	Ext.
C7h	Extension command disable (for Axh, Bxh).	Ext.
D0h	DMA pause.	Comp.
D1h	Voice DAC mixer input enable.	Comp.
D3h	Voice DAC mixer input disable.	Comp.
D4h	Continue DMA after D0h command.	Comp.
D5h	ES488 compatibility command - returns 1.	Ext.
D6h, D7h	ES488 compatibility commands-no effect.	Ext.
D8h	Voice DAC status return - 0 = disabled, FFh = enabled.	Comp.

ES1869 Extension Commands (Axh, Bxh, Cxh, Read/Write)

The ES1869 component supports a group of commands that provide additional functions not supported in by industry standard sound adapter compatible mode. Each of these commands has an associated register that is written when a command write occurs. A write process consists of first writing the command to 02nCh followed by the data.

Writing example:

```
Out 02nCh, Reg Nr   ; Register number to write to
Out 02nCh, Data     ;Desired register contents in hex
```

A read of an extension command register is accomplished with the C0h command.

Reading Example:

```
Out 02nCh, C0h      ;enable 1869 read
Out 02nCh, Reg Nr   ;Register number to read from
In, 02nAh           ;get the register contents
```

The read data available bit should be polled before reading the register contents.

Sample Rate Generator Register (A1h, Read/Write)

This 8-bit register holds the 2's compliment sample rate divider value that should be programmed for all ADC and DAC operations in extended mode. The sample rate is determined using the following formulas:

Bit <7> = 0, then 397.7 kHz / (128-X) = Sample Rate

Bit <7> = 1, then 795.5 kHz / (256-X) = Sample Rate where X = value of bits <6..0>.

Aih

BIT	FUNCTION
7	Sample Rate Clock Source Select: 0 = 397.7 kHz (sample rate <= 22 kHz) 1 = 795.5 kHz (sample rate > 22 kHz)
6..0	Sample Rate Divider Value

Filter Divider Register (A2h, Read/Write)

This 8-bit register determines the low pass frequency of the switched capacitor filters inside the ES1869. The filter clock frequency will be the roll-off frequency (80% of the sample rate divided by 2) multiplied by 82. The following formula is used by the register to determine the filter clock frequency:

7.16 MHz / (256-X) = Filter Clock Frequency where X = value of bits <7..0>.

DMA Transfer Counter Reload Registers (A4h, A5h Read/Write)

These registers hold the 16-bit 2's complement value that is copied into the FIFO transfer control counter after each overflow (and at the beginning of the initial DMA transfer). Register A4h is the low byte counter value, and A5h is the high byte counter value. The counter is incremented after each successful byte is transferred by DMA.

Program Type Register (A8h Read/Write)

This register selects either mono or stereo mode for DMA recording or playback.

A8h

BIT	FUNCTION
	Reserved.
3	DMA Playback - Reserved. DMA Record Monitor: 0 = Record Monitor disable 1 = Record Monitor enable
1,0	Program Type: 10 = Mono 01 = Stereo

Interrupt Control Register (B1h, Read/Write)

This register determines IRQ generation by the **ES1869** component during audio operations.

B1h, Read/Write

BIT	FUNCTION
7	Processor IRQ: 0 = IRQ generation is disabled (extended mode) 1 = IRQ generation is enabled (compatibility mode)
6	DMA Counter Overflow IRQ: 0 = IRQ not generated 1 = IRQ generated for DMA counter overflow
5	FIFO Half-Empty IRQ: 0 = IRQ not generated 1 = IRQ generated for FIFO transitions (ext. mode)
4	IRQ Enable: 0 = All IRQs disabled 1 = IRQ generation is enabled
3..0	Interrupt Select: 0000= IRQ2, 9, all others 0101 = IRQ5 (default) 1010 = IRQ7 1111 = IRQ10

DMA Control Register (B2h, Read/Write)

This register determines DRQ generation by the ES1869 component during audio operations.

B2h, Read/Write

BIT	FUNCTION
7	Reserved for Game Compatible DRQ: (left at zero for Extended Mode)
6	Extended DMA DRQ: 0 = DRQ not generated (block I/O w/FIFO in ext. mode) 1 = DRQ generated for DMA in extended mode
5	Enable Game Compatibility DMA DRQ: 0 = DRQ not generated 1 = DRQ generated for DMA in game compatibility mode
4	Don't Care.
3..0	DMA Channel Select (Read Only): 0000 = All others selected 0101 = Ch 0 1010= Ch 1 1111 = Ch 3

Input Volume Control Register (B4h, Read/Write)

This register controls the stereo input volume. Each channel has 4 bits of resolution control, with a range of 0 dB to +22.5 dB in 1.5 dB steps. The low nibble (bits 3..0) controls the left volume, and the high nibble (bits 7..4) controls the right volume.

DAC/ADC Initialize and Configuration Registers (B6h, B7h Read/Write)

These registers are used to configure the DAC and ADC for a specific data format for playback (DAC) or record (ADC). Between the six format parameters (mono/stereo, 8-/16bit, and signed/unsigned), eight formats are available. The table below shows how registers B6h and B7h are set for the desired format. Note that B7h receives two bytes.

Table 7-8
DAC/ADC Configuration Register Loading

Format	Register B6h*	Register B7h
Mono, 8-Bit, Unsigned	80h	51h, D0h
Mono, 8-Bit, Signed	00h	71h, F0h
Mono, 16-Bit, Unsigned	80h	51h, D4h
Mono, 16-Bit, Signed	00h	71h, F4h
Stereo, 8-Bit, Unsigned	80h	51h, 98h
Stereo, 8-Bit, Signed	00h	71h, B8h
Stereo, 16-Bit, Unsigned	80h	51h, 9Ch
Stereo, 16-Bit, Signed	00h	71h, BCh

***Register B6h is used only when configuring the DAC (playback).

FM Synthesis Control Registers

The FM synthesis logic is typically mapped at 0388h-038Bh. A total of 243 control registers divided into two banks are available. The FM synthesis control registers are accessed by first writing the address of the control register to 0388h (for bank 0) or 038Ah (for bank 1) followed by writing the data to either 0389h or 038Bh. If a succeeding data byte is destined for the same control register, that control register's address need not be rewritten. FM synthesis is a write-only operation, as only one read, for status, is permitted. Table 7-9 lists the mapping of the FM synthesis logic.

Table 7-9
FM Synthesis Mapping

Address	Register	R/W
0388h	FM Synthesizer Register Address Write (Bank 0)	WO
0388h	FM Synthesizer Status Register	RO
0389h	FM Synthesizer Register Data Write	WO
038Ah	FM Synthesizer Register Address Write (Bank 1)	WO
038Bh	FM Synthesizer Register Data Write	WO

Table 7-10 lists the control registers for FM synthesis. Refer to the data sheet for the ES1869 for detailed register information.

Table 7-10
FM Synthesis Control Registers

Address	Bank 0 Function	Bank 1 Function
01h	Test - all 0s	Test - all 0s
02h	Timer 1	Not Used
03h	Timer 2	Not Used
04h	Timer Mask/Timer Start	4-Operator Configuration.
05h	Not Used	4-Operator Enable
08h	Key Scale (KSR) # Determiner	Not Used
20h-35h	AM*, VibratoVib, EG Type, KSR, Mult.	Same as bank 0
40h-55h	Key Scale Level, Tone Level	Same as bank 0
60h-75h	Attack Rate, Decay Rate	Same as bank 0
80h-95h	Sustain Level, Release Rate	Same as bank 0
A0h-A8h	Freq. Number	Same as bank 0
B0h-B8h	Key On, Block Octave, Freq. No.	Same as bank 0
BDh	Depth. of AM*/Vibrato, Rhythm Mode	Not Used
C0h-C8h	Stereo Left/Right, Feedback, Conn.	Same as bank 0
E0h-F5h	Wave Select	Same as bank 0

***** Tremolo
****** Oscillator configuration

Audio Subsystem Specifications

Table 7-11 lists the specifications for the audio subsystem.

Table 7-11
Audio Subsystem Specifications

Parameter	Minimum	Nominal	Maximum
Input Level:			
Microphone	10 mV	—	125 mV
Line	0.5 V	—	3.00 V
Input Impedance:			
Microphone	—	4 k ohms	—
Line	—	20 k ohms	—
Internal Microphone Sensitivity	—	-50db	—
Output Power (both channels)	—	0.45 watts rms. @ 8 ohms	—
Headphone Output Impedance	8 ohms	32 ohms (recommended)	—