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Fully Digitized Audio System



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Field of The Invention

5 [0001] The present invention relates to an audio system, more particularly to a fully digitized audio system designed on the basis of mechatronics.

Related Art

10 [0002] Audio system is everywhere nowadays. The acoustics requirements on audio systems, especially on domestic systems, are increasingly so strict that super hi-fis has already been put into consideration. The conventional audio systems are designed on the basis of analogue signal propagation and process, with the exception of some partial circuits such as digital audio signal sources and decoding circuits
15 for respective digital signal sources. The existing digital circuits in conventional systems, though, are partial or substitutionary modules of analogue nature. The limitations of analogue circuits result in distortions in audio signals occurring at various links throughout the chain from input via process, transmission, amplification and etc. to loud-speaking, and
20 difficulties in design and manufacture as well. Since, especially, the amplification circuits and loudspeakers of conventional audio systems are not designed as integrated systems (not designed according to mechatronics), there are, of course, many problems encountered which are difficult to be overcome systematically, and mainly consist in following
25 aspects:

1. difficulties in load matching between an amplifier and a loudspeaker/loudspeakers;
2. linear and non-linear distortions resulted from analog amplification (including voltage pre-amplification and power
30 output amplification);

3. distortions and power losses resulted from passive power frequency dividers (increase in the output internal impedance towards loudspeaker units and decrease in compliance);
4. complexities and difficulties in manufacturing and adjusting a sound box;
5. difficulties in handling phase-frequency distortion or transient distortion due to high complication of the phase-frequency characteristics of an entire system ranging from amplifiers to loudspeakers;
6. inefficiency in power amplification resulting in a very expensive manufacture cost for power amplification units in hi-fi systems; and
7. much more difficulties in design and manufacture of AV hi-fi systems with uncertainties about consistency among products.

Summery of The Invention

[0003] It is an object of the present invention to provide a fully digitized audio system adopting digital transmission and digital process for the whole procedure, in which the sound box, due to an integrated mechatronic structure, offers high fidelity, higher controllability, easy assembling, convenience in manufacture and adjustment, as well as a higher performance/price ratio.

[0004] The above object of the invention can be achieved by a fully digitized audio system including a decode and sound field acoustics effect process unit as well as a power supply, characterized in that digital audio signals outputted from a decode and sound field acoustics effect process unit is fed to a control and encode unit, where the audio signal and control signal are encoded and coupled with a digital sound box unit via a digital transmission terminal in the control and encode unit.

[0005] The object of the invention can be further achieved

through following features: the control and encode unit includes a digital audio signal channel divider, a volume and function controller, a digital audio and control encoder and a digital transmission terminal, wherein, upon the digital audio signal from the decode and sound field acoustics effect process unit is processed by the digital audio signal channel divider, the control signal from the volume and function controller and other corresponding control signals are encoded into a digital audio signal through the digital audio and control encoder, such that a standard encoded audio digital signal stream containing control information is formed and outputted from the digital transmission terminal. In addition, the volume & function controller is able to control a gate circuit and an acoustics effect processor. A digital sound box unit includes a digital box terminal, a digital sound box signal processor, a power amplifier, a loudspeaker unit and sound boxes. The standard encoded audio digital signal stream from the digital transmission terminal is, after being fed into the digital sound terminal, subjected to digital frequency division, digital phase-frequency correction, digital amplitude-frequency correction, digital volume control and digital peak value correction through the digital box signal processor and, then, divided into two or more channels of digital audio signals with different responsive frequency band to be fed to amplifiers and, finally, to drive the loudspeaker unit. The digital sound box unit also feeds the condition signal related to the digital sound box back to the control and encode unit through the digital sound box terminal and the digital transmission terminal. The digital sound box signal processor, the speaker unit and the box are in a mechatronics structure. The decode and sound field acoustics effect process unit includes a digital audio source, a digital audio source input connector, an analog audio source, an analog audio source input connector, an analog-to-digital (A/D) converter, a gate circuit, an acoustics effect processor. The acoustics effect processor can

output two or more channels of digital audio signals to the control and encode unit. Further, parameters such as cut-off frequency, amplitude-frequency correction, phase-frequency correction and peak value correction of the digital sound box signal processor in the digital sound box unit can be adjusted by a sound box parameter adjustment unit.

[0006] The control and encode unit of the present system receives digital audio signal inputted and/or digitized analog audio signal from a standard connector, signals passed over from a control interface and sound box condition signals fed back via the digital transmission terminal. Various signals are processed and encoded digitally in the volume and function control unit and the control and encode unit. The encoded data stream is outputted through the digital transmission terminal. The standard encoded audio digital signal stream outputted from the control and encode unit is fed to the digital sound box, and feedback signals from the digital sound box are sent back to the control and encode unit via the digital transmission terminal, transmission media and the digital sound box terminal. The sound box and the digital sound box unit adopt digital and mechatronic conception, wherein the standard encoded digital audio signal stream fed from control and encode unit, through the digital transmission terminal, is subjected to steps of separating the audio signal from the control signal, digital frequency division, digital phase-frequency correction, digital amplitude-frequency correction, digital volume control and digital peak value correction through the digital box signal processor, especially predictive digital phase-frequency correction, digital amplitude-frequency correction as well as setting of control parameters thereof, so as to ensure high fidelity and high stability for the audio output from the digital sound box unit. The digital sound box unit also feeds various related signals back to the control and encode unit through the digital sound box unit terminal and transmission media.

[0007] The present invention has following advantages over prior

art:

[0008] 1. distortions caused by conventional analogue transmission and analog circuits being reduced, thanks to a whole procedure of digital signal transmission and process adopted by the integrated system.

5 [0009] 2. a dramatically increase in electric damping of power amplification to loudspeaker due to the adoption of digital frequency division.

[0010] 3. guaranteed high fidelity and high resolution provided by accurately adjusted amplitude-frequency and the phase-frequency characteristics by means of predictive and adaptive compensation through the whole procedure (mainly for the amplitude-frequency distortion and phase-frequency distortion resulted from the speaker unit, the sounding plane of each speaker unit, sound box, digital divider, amplifier, and etc.)

10 [0011] 4. the sound box integrate (including the circuit, the loudspeakers and the box) based on mechatronics design, easy to be adjusted and resulting in higher performance and simplification in design.

[0012] 5. standardized interfaces enabling any manufactory to produce sound boxes of highest fidelity according to the present system.

15 [0013] 6. suitable to mass production, in particular, of AV5.1 (or above) channel hi-fi system due to the design principles of the present system which makes the production cost reduced, and the process simplified.

[0014] 7. easy arrangement of a whole set of system, resulting in a reduced update expenditures.

20 [0015] 8. acoustics or tone quality accomodatable according to individual favorites due to the hi-fi platform structure design of the present system and advanced digital signal process.

[0016] 9. diversified sound field scene effects.

30 Brief Description of The Drawings

[0017] Figure 1 is a block diagram showing the circuit principle of the present invention;

[0018] Figure 2(A) to 2(D) are block diagrams showing the four possible forms of control and encode unit;

5 [0019] Figure 3(A) to 3(D) are block diagrams showing four possible manners of connection between control and encode unit and the power supply;

10 [0020] Figure 4(A) to 4(C) are block diagrams showing three possible manners of connection between control & encode unit and digital speaker; and

[0021] Figure 5(A) and 5(B) are block diagrams showing two possible manners of the digital sound box unit.

Detail Description of Preferred Embodiment

15 [0022] Now the present invention will be described in detail by means of preferred embodiments in conjunction with the accompanying drawings.

20 [0023] As shown in Fig 1, a system according to the present invention comprises a decode and sound field acoustics effect process unit 20, a power supply 21, a control and encode unit 18, a digital sound box unit 19 and a sound box 17. The decode and sound field acoustics effect process unit 20 comprises a digital audio source 1, a digital audio source input interface 2, an analog audio source 3, an analog audio source input interface 4, an A/D converter 5, a gate circuit 6 and an acoustic effect processor 7. The control and encode unit 18 comprises a digital audio signal channel divider 8, a volume and function controller 9, a digital audio code and control code encoder 10 and a digital transmission terminal 11. The digital sound box unit 19 comprises a digital sound box unit terminal 13, a digital sound box unit signal processor 14, a power amplifier unit 15 and a speaker unit 16. As an optional, a speaker

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parameter adjuster may be provided for a user to further regulate the box parameters.

[0024] control and process:

[0025] The signal from the analog audio source 3 is sent to the analog audio source input interface 4 of the decode and sound field acoustics effect process unit 20 of the present system. At first, the signal from analog audio source is digitized, generally by the A/D converter 5. The digital audio source 1 is directly coupled with an input interface of the digital audio source 2 of the decode and sound field acoustics effect process unit 20 according to the present system such that upon being selected from multiple input by a gate circuit 6, the digital signals of audio source are digitally decoded and processed for digital sound field effect (may include many functional processes such as Dolby surround, Dolby digital (AC-3), DTS, DSP sound field, digital 3D sound field, digital Karaokey, digital equalize and etc.). Two or more channels of digital audio signals are outputted and divided into corresponding channels by the digital audio signal channel divider 8 in the control and encode unit 18. And then beginning from the digital signal stream, signals from the volume and function controller 8 and other corresponding control signals (for example, the volume control signal, post-process control signal and mode selection control signal) are encoded, through the digital audio code and control code encoder 10, into a digital signal stream to form a standard encoded audio digital signal stream containing control information which is outputted from the digital transmission terminal 11.

[0026] The volume and function controller 9 can also be used to control the gate circuit 6, the effect processor 7 and other units (for example a display unit).

[0027] Transmission:

[0028] The transmission of the standard encoded audio digital signal stream of the present system takes the form of a variety of standard

serial protocol, for example the standard S/PDIF protocol. The digital audio signal is carried in an audio data area of the S/PDIF whereas the audio data area is defined as single-channel mode (or only one of the double-channel used). The volume and control codes, encoded digitally, are loaded in a user code area (Ubit). The volume and control codes encoding is adopted as a reliable (with check and correction) and connectionless (real time) method.

[0029] The type of the transmission medium at physical level 31 is selected mainly according to the principle of high rate and long distance, wherein the data rate must be more than 96K/32Bit and the distance to be transmitted is over 15 meters. Thus, for example, optical fiber, coaxial cable or twisted pair line may be used.

[0030] If the structures shown in figures 4A, 4B, 4C are adopted, it is suggested that a pair of twisted wires be used as the transmission medium. Then the standard encoded audio digital signal stream is modulated by a digital signal modulator 29, then is mixed with the power supply 21 from mains 32 by a digital audio signal mixer via a power distributor 22 and a power mixing network 24 prior to being transmitted by a pair of wires. On the digital sound box unit port 13 the modulated standard encoded audio digital signal stream is separated from the power by means of the digital audio signal separation network 33 and the power separation network 34, whereby the power is fed into a sound box power supply 35 while the modulated standard encoded audio digital signal stream is fed into the digital sound box signal processor 14 after demodulated by a digital audio signal demodulator 30.

[0031] If the structure shown in the figure 4D is adopted, power for the sound box can be supplied directly from mains 32 through a sound box power supply 35.

[0032] After being fed into the circuit of the digital sound box terminal 13, the standard encoded audio digital signal is processed,

including digital frequency division, digital phase-frequency correction, digital amplitude-frequency correction, digital volume control and digital peak value correction by the digital sound box signal processor 14, divided into two or more channels of digital audio signals with different response spectrum and sent to a power amplifier 15 to drive the speaker unit 16 finally. The digital sound box unit 19 also feeds related condition signals back to control and encode unit 18 via the digital sound box terminal 13 and digital transmission terminal 11.

[0033] The sound box 17 and digital speaker 19 are designed according to mechatronics conception and adopt predictive compensation, which further optimizes the design of the sound box unit, and allows following design ideas to be realized much easily.

[0034] Digital frequency division:

[0035] The object of digital division is to divide the whole spectrum of an audio signal into two (or three or more) digital audio channel signals of low, mid in some case and high frequency ranges so as to drive bass, flat in some case and treble speaker units respectively after being processed. The lowpass, bandpass in some case and highpass used by the present system are implemented with digital filters of appropriate orders and appropriate types. Digital division allows to improve the electrical damping performance of the power amplifier towards the speaker unit, to use a more accurate and higher orders of frequency division resulting in a less band overlapping between both speaker units, and a reduced phase distortion.

[0036] Digital phase-frequency correction:

[0037] The aim of the digital phase-frequency correction is to correct phase-frequency distortion at all links of the system, especially the phase-frequency distortion caused by the difference between sounding plane of speaker units, to make the systematical "group delay" through the active spectrum of the sound boxes constant (linear phase-frequency).

[0038] Digital amplitude-frequency correction:

[0039] The object of the digital amplitude-frequency correction is to correct the amplitude-frequency distortion resulted from such links as sensitivity of the speaker units, sound box 17 and etc., to make the amplitude-frequency characteristics through the active spectrum of the sound boxes to be flat.

[0040] Digital volume control:

[0041] The function of the digital volume control is to receive volume control signals from control and encode unit 18, and modulate the digital audio signal in order to control volume. Furthermore, the maximum volume of the loudspeaker unit 16 is necessary and possible to be limited to prevent the speaker from being burnt down because that the sensitivity of the loudspeaker unit 16, the power applied to the speaker unit 16 and amplification factor of the system are given (due to mechatronic design),.

[0042] Digital peak correction:

[0043] Because both voltage applied to the amplifier 15 and peak power bearable by the speaker unit 16 are limited, an excessive peak power output causes serious chopping distortion which is necessary and possible to be corrected in the present system. The desired correction is possible by predicting following signal amplitude and adopting a method of gradual changing curve (soft saturation). After being corrected, the system performance and acoustics would be improved dramatically, resulting in smooth and graceful melodies.

[0044] The above-mentioned processes are based on the design concept of mechatronics and determined by the characteristics of speaker unit 16 and sound box 17, tested during design and manufacture. In general, a top level of hi-fi is achieved by making sure that the distortions through all links of the system (especially the sound box 17 and the speaker unit 16) be compensated in a predictive way.

[0045] By the way, manufactures and designers of sound boxes

can accommodate timbre inclination of sound boxes, dynamic tendencies and local style inclination, according to their own ideas of design, so that products of unique brand style can be formed.

[0046] Further, users can enjoy their acoustics favorites by adjusting the setting of sound field or equalizer of the effect processor 7 of the present system.

[0047] Senior audio fans can even adjust the parameters of cut-off frequency, amplitude-frequency correction, phase-frequency correction and peak correction of the digital sound box unit signal processor 14 of the system through speaker parameter adjuster 12, to satisfy the individual taste of his own, or exchange experiences with other fans, or even take part in competitions.

[0048] Since the standard encoded audio digital signal stream is adopted in the data transmission of the present system, the independence from each other between the control & encode unit 18 and the digital speaker system 19 is ensured. In addition, because the digital sound box unit system is designed and manufactured under an integrated and high fidelity required architecture, independently from system specialties, the interdependency among various parts is reduced, allowing independent design and manufacture of separate various parts.

[0049] Referring to figure 2A to 2D, control and encode unit 18 in the structure shown in figure 2A is an independent device characterized in that the structure is clear but there are many connecting lines. Additionally, there are no available products of the decode and sound field acoustics effect process unit 20 which are suitable to be arranged in the present system. Control and encode unit 18 and the decode and sound field effect process unit 20 shown in figure 2B are in a combined structure, but the power distributor 22 is independent, thus allowing that the power supply can be selected freely. As shown in figure 2C a power distributor 22 is combined into the structure, making it easy to be

installed. As shown in figure 2D, a CD, DVD driver 28, and the basic AV functions are combined together to form an AV audio system without additional devices. The structures shown in figure 2C and 2D are more practical.

5 **[0050]** Referring to figure 3A to 3D, the power supply 21 in figure 3A is disposed within the device. The power supply 21 in figure 3B is disposed outside of the device, connected through an interface. The power supply 21 in figure 3C is combined with the power distributor 22 and separated from the device. In figure 3D the power is directly supplied to
10 the digital sound box unit 19. Each of the structures shown in figure 3A to 3C has its own advantages. But it is more difficult to connect lines for the structure shown in figure 3D.

[0051] Referring to figure 4A to 4c, figure 4A corresponds to figure 3A and 3B. The digital audio signal separation network 33 allows
15 modulated digital signal to be passed but inhibits power signal of low frequency, while the power separation network 34 allows power signal of DC or AC (50Hz~60Hz) to be passed but inhibits high frequency digital signal. Figure 4B corresponds to figure 3C while figure 4C corresponds to figure 3D where the power 35 is arranged according to the sound box its
20 self.

[0052] Referring to figure 5, the amplifier 15 shown in figure 5A is a sounding structure in which a digital power amplifier 25 (such as a class D amplifier) is adopted to drive loudspeaker units 16 directly. The amplifier 15 shown in figure 5B is a sounding structure in which the
25 speaker unit 16 is driven through digital/analog converter 26 prior to an analogue power amplifier 27.

Claims

1. A digital audio system comprising a power supply (21) and a decode and sound field effect process unit (20), wherein digital audio signals outputted from the decode and sound field effect process unit (20) are transmitted to a control and encode unit (18) where audio and control signals are encoded and coupled with a digital sound box unit (19) via a digital transmission terminal in a control and encode unit (18).

2. A system according to claim 1, wherein control and encode unit (18) comprises a digital audio signal channel divider (8), a volume and function controller (9), a digital audio code and control code encoder (10) and a digital transmission terminal (11), whereby after the digital audio signals from the decode and sound field effect process unit (20) are processed by the digital audio signal channel divider (8), the control signal of the volume and function controller (9) and other corresponding control signals are encoded into the digital audio signal by the digital audio code and control code encoder (10), to form a standard encoded audio digital signal stream containing control information, which is outputted from digital transmission terminal (11).

3. A system according to claim 1, wherein the digital sound box unit (19) comprises a digital sound box unit terminal (13), a digital sound box unit signal processor (14), a power amplifier (15), a speaker unit (16) and a sound box (17), whereby the standard encoded audio digital signals stream outputted from the digital transmission terminal (11) are fed to the digital sound box unit terminal, subjected to digital division, digital phase-frequency correction, digital amplitude-frequency correction, digital volume

control and digital peak value correction through the digital sound box unit signal processor (14), and then divided into two or more channels of digital audio signals to be fed into amplifier (15) to drive the speaker unit (16) finally.

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4. A system according to claim 3, wherein, a condition signal related to the digital sound box unit is fed back to the control and encode unit (18) from the digital sound box unit (19) via the digital sound box unit terminal (13) and the digital transmission terminal (11).

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5. A system according to claim 1 or 2, wherein the signal processor (14), the speaker unit (16) and the sound box (17) of the digital sound box unit (19) take a mechatronic configuration.

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6. A system according to claim 1 or 2, wherein the decode and sound field effect process unit (20) comprises a digital audio source (1), a digital audio source input interface (2), an analog audio signal source (3), an analog audio source input interface (4), an A/D converter (5), a gate circuit (6) and an effect processor (7) which can output two or more channels of digital audio signals to the control and encode unit (18).

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7. A system according to claim 6, wherein the volume & function controller (9) may control the gate circuit (6) and the effect processor (7).

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8. A system according to claim 1 or 4 or 5, wherein the parameters such as cut-off frequency(ies), amplitude-frequency correction, phase-frequency correction and peak value correction of the digital sound box unit signal processor (14) in the digital sound

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box unit (19) can be adjusted by a speaker parameter adjuster (12).