

Description

This invention relates to an apparatus for reproducing audio signal which is digitally processed from the recording medium and, more particularly, to such apparatus for reproducing audio signal in which the reproducing speed and the sound pitch (key) may be variably controlled independently of each other. The invention also relates to an apparatus for reproducing audio signal for used with a player system adapted for reproduction of for example a performance of the background orchestra without the singer's voice (so-called "kara-oke") previously recorded on the recording medium.

10 BACKGROUND ART

In the signal reproducing apparatus such as the commonplace audio tape recorder or disk player, it is well-known that, when the reproducing speed, i.e. the speed at which audio signals recorded on a recording medium are reproduced, is changed with respect to the recording speed, i.e. the speed at which the audio signals are previously recorded on the recording medium, not only the reproducing speed or tempo but also the sound pitch or key is changed. That is, the higher the reproducing speed, the higher the sound pitch and, conversely, the slower the reproducing speed, the lower sound pitch.

In the apparatus for reproducing audio signal such as a performance of the background orchestra without the singer's voice (hereafter called "kara-oke"), there are presented in the art various audio signal reproducing apparatus which is provided with such a reproducing function that the tempo or reproducing speed may be variably and arbitrarily set so that a "kara-oke" may be reproduced at the tempo desired by the singer. In the signal reproducing apparatus provided with such the variable speed reproducing function, the sound pitch or key is necessarily changed with changes in the reproducing speed. By this reason, a signal processing device provided with the function of changing the pitch or key of the reproduced audio signals is used for effecting a pitch conversion in such a manner that the pitch or key of the reproduced audio signals is not changed even though the reproducing speed is changed so that the reproduced audio signals may have approximately the same pitch as that used during the original recording.

The above mentioned signal processing apparatus are known in the art in which analog delay elements such as BBDs (bucket brigade devices) or CCDs (charge coupled devices) are used and the read or write clocks thereof are chronologically changed for controlling the delay time, or in which input audio signals are converted into digital signals and digital delay elements such as shift registers or RAMs (random access memories) are used for effecting time base compression and expansion through control of the writing and read-out operations.

The conventional type of the audio signal reproducing apparatus is constructed in the following manner. That is, with the tape recorder or the disk player, the running speed of the recording medium such as the magnetic tape or the disk (tape speed or rotating speed) is controlled by the reproducing speed control device so that the reproduced audio signals are reproduced from the variable speed reproducing apparatus and converted in pitch in the pitch conversion unit to be supplied at the signal output terminals. Information signals indicating changes in the reproducing speed are supplied from the reproducing speed control unit to the pitch conversion unit, which then performs a pitch conversion so that the sound pitch of the reproduced audio signal is lowered to $1/m$ times the standard sound pitch when the variable speed reproducing unit is operating at a speed m times the standard speed.

In the above described type of the conventional audio signal reproducing apparatus for processing the pitch conversion of the reproduced audio signal, there is required information indicating the ratio of the change caused in the reproducing speed. In addition, the variable speed reproducing unit and the variable speed control unit need to be controlled at all times under a predetermined relation to each other. Thus it is not feasible to variably independently control the tempo and the key of the reproduced audio signals.

In "kara-oke" reproduction, not only are any tunes selectively reproduced, but the singers usually take their turns by rotation. With the audio signal reproducing apparatus used for "kara-oke" reproduction, the pitch conversion unit operates in the previous setting even when the tunes and/or the singers are changed, thus embarrassing the singers.

US-A-4365115 discloses a device in accordance with the pre-characterising portion of claim 1 in which data reproduced at different speeds can be frequency compensated by reading it out of a memory at a different rate to that used to write it to the memory. The read and write rates are controlled by separate oscillators.

According to the present invention there is provided an apparatus for reproducing an audio signal comprising:

a reproducing unit for reproducing a data signal including audio signal data at an arbitrary α -times of a

predetermined speed from a medium on which the audio signal data is previously recorded at the predetermined speed and at a predetermined sampling frequency (F_s);

a pitch conversion unit having a memory into which the audio signal data obtained from said reproducing unit are written according to a write clock signal corresponding to the reproducing speed and from which the audio signal data are read out according to a read clock signal corresponding to an arbitrary β -times of the predetermined speed;

wherein α and β are relatively changeable; characterised by

means for producing from the reproduced data signal (S_{PB}) the write clock signal having a reproducing sampling frequency (F_s) equal to α -times the predetermined sampling frequency; and

means for producing the read clock signal having a frequency f_p ($=\beta F_s$) which is β -times of the predetermined sampling frequency F_s .

Thus with the present invention the apparatus for reproducing audio signal is through the combination of the digital signal reproducing unit and the pitch conversion unit able to variably independently control the reproducing speed and the sound pitch of the reproduced audio signals.

Further, the apparatus may include means such that the pitch conversion ratio can be automatically set to a predetermined value for each tune of the reproduced audio signals reproduced by the audio signal reproducing unit for improving the operability of the audio signal reproducing system adapted for "karaoke" reproduction and the like.

The following description is given by way of example only with reference to the accompanying drawings in which:-

Figure 1 is a block circuit diagram showing an embodiment of the apparatus for reproducing an audio signal according to the present invention which is applied to a compact disk player.

Figure 2 is a schematic diagram showing the recording format of the compact disk of figure 1;

Figure 3 is a block diagram showing a constructional example of the apparatus of figure 1;

Figure 4 is a block diagram showing a modification of the pitch ratio control unit in the circuit of figure 3;

Figure 5 is a schematic diagram showing the changing state of the RAM addresses in the apparatus of figures 1, 3 and 4;

Figure 6 is a time chart showing the operation of the RAM for effecting pitch conversion;

Figures 7 and 8 are waveform diagrams showing the operation of the apparatus for reproducing audio signal.

The whole construction of an apparatus, in which the present invention is applied to a so-called compact disk player, is shown in the block diagram of figure 1. The apparatus comprises a player unit 10 by which the audio signal data with a predetermined sampling frequency F_s recorded on a compact disk 11 along with control data are reproduced with a variable speed; a pitch conversion unit 20 by which the reproduced audio signal data from the player unit 10 are subjected to a pitch conversion process; and a digital to analog (D/A) converter 30 by which analog reproduced audio signals are formed from reproduced audio signal data pitch-converted in the pitch conversion unit 20.

On the compact disk 11, as shown in Fig. 2, data are recorded in a frame format configuration with each frame consisting of synchronizing signal bits, users' bits, audio data bits and error correction bits, of total 588 bits. In the users' bits, the data indicating the presence or absence of musical sounds, are recorded in the P channel while the data indicating the number of channels, the presence or absence of emphasis, the absolute addresses, tune number, index numbers in the tune, etc. are recorded in the Q channel.

In the player unit 10, while the compact disk 11 is driven in rotation by means of a disk driver 12, the data recorded on the disk 11 are read by a pick-up, not shown, so as to obtain reproduced digital signals S_{PB} , which are then processed by a signal processor section 13 for reproducing the synchronizing signal or users' bit data so as to control the driving system and for reproducing and outputting PCM digital signal S_{PCM} representing music. In the player 10 of the present embodiment, the signal processor section 13 produces end signal S_{END} indicating the end of the musical sound on the basis of the P channel data of the users' bits, thereafter end signal S_{END} is supplied to the pitch conversion unit 20 along with the PCM digital signals S_{PCM} . The player unit 10 is also provided with a variable oscillator 15 of which the oscillating frequency f_o is controlled by speed control signals supplied from a reproducing speed control section 14. The rotation of the disk driver 12 is servo-controlled by a rotation control section 16 in such a manner that the reproduced digital signal S_{PB} is derived in synchronism with the oscillating frequency f_o .

The reproducing speed control section 14 outputs a speed control signal indicating a magnifying factor α referenced to the standard reproducing speed, which is supplied to the oscillator 15 such that $\alpha=1$ during standard speed reproduction, $0<\alpha<1$ during low-speed reproduction and $1<\alpha$ during high-speed reproduction.

The oscillator 15 is driven at a oscillating frequency f_o such that

$$f_o = \alpha \cdot F_o \quad (1)$$

wherein F_o indicates the oscillating frequency for $\alpha=1$, that is, for the standard speed reproduction during which the audio signal data with the aforementioned predetermined sampling frequency F_s is reproduced as it is from the compact disk 11. The rotation control section 16 controls the rotating speed of the compact disk 11 in synchronism with the oscillation frequency f_o . The signal processor section 13 also operates to process the signal in synchronism with the oscillating frequency f_o .

Thus, in the player unit 10, the PCM digital signals S_{PCM} with the reproducing sampling frequency f_s such that

$$f_s = \alpha \cdot F_s \quad (2)$$

are outputted from the signal processor section 13 as the reproduced audio signal data. In the equation (2), F_s denotes the reproducing sampling frequency for standard speed reproduction, which is equal to the aforementioned predetermined sampling frequency at which the audio signal data are recorded on the compact disk 11.

The end signal S_{END} as well as the PCM digital signal S_{PCM} as the reproduced audio signal data from the player unit 10 are supplied to the pitch conversion unit 20 which is comprized of a pitch conversion processor section 21 and a pitch ratio control section 22. The PCM digital signal S_{PCM} undergoes a pitch conversion at the pitch conversion processor section 21 in accordance with the pitch ratio control signal supplied from the pitch ratio control processor section 22.

The pitch conversion is effected at the pitch conversion processor section 21 with the aid of memory means, not shown, in such a manner that the data of the PCM digital signal S_{PCM} are written in the memory means by the write clock signal that is timed to the reproducing sampling frequency f_s of the PCM digital signal S_{PCM} supplied from the player unit 10 and the data are read out from the memory means by the read clock signal that is timed to the post-conversion sampling frequency f_p .

It should be noted that a pitch ratio control signal which will give a sampling frequency f_p such that

$$f_p = \beta \cdot F_p \quad (3)$$

is supplied from the pitch ratio control section 22 to the pitch conversion processor section 21, where β represents the pitch ratio referenced to the sound pitch of the reproduced audio signals during the aforementioned standard speed reproduction. In the above equation (3), F_p represents the sampling frequency for $\beta=1$, that is, that employed during the standard speed reproduction and equal to the aforementioned predetermined sampling frequency F_s .

In the pitch conversion unit 20 of the present embodiment, the ratio γ between the sound pitch of the original signals as the audio signal data recorded on the compact disk 11 and the sound pitch of the reproduced signals as reproduced audio signal data converted in the sound pitch, is given by

$$\gamma = f_p / F_p \quad (4)$$

Since $F_s = F_p$, the following equation

$$\gamma = \frac{f_p}{F_s} = \frac{\beta F_p}{F_s} = \beta \quad (5)$$

is derived from the equations (3) and (4). Thus the sound pitch of the reproduced signals is not influenced by the reproducing speed employed in the player unit 10 but may be determined solely by the pitch ratio β . It should be noted that the actual ratio δ in the pitch conversion employed at the pitch conversion processor section 21 is given by

$$\delta = \frac{f_p}{f_s} = \frac{\beta f_p}{\alpha f_s} = \frac{\beta}{\alpha} \quad (6).$$

5

Thus, the pitch conversion is effected in the pitch conversion processor section 21 by a factor of $1/\alpha$ even when $\beta=1$ and the output from the pitch conversion unit 20 is the conversion output for $\beta=1$.

The pitch-converted PCM digital signal are converted at the D/A converter 30 into an analog form and the resulting analog signals are outputted at a signal output terminal 40 as reproduced audio signals with
10 the reproducing speed or tempo as set with α and the sound pitch or key as set with β .

The tempo and the sound pitch of the reproduced audio signal obtained at the output terminal 40 can be controlled by the factors α and β independently of each other. In addition, any jitter components in the time base occasionally included in the reproduced PCM digital data obtained in the player unit 10 can be automatically compensated in the pitch conversion unit 20.

15 In the present embodiment, the pitch ratio β afforded in the pitch ratio control section 22 can be set arbitrarily and, it is set prior to actual performance. The pitch ratio control section 22 is adapted to be reset to the state of $\beta=1$, that is, to the normal pitch for the standard speed reproduction, whenever the end signal S_{END} is supplied from the player unit 10.

The pitch conversion unit 20 of the present embodiment can be constructed, for example, as the block
20 circuit diagram shown in Fig. 3.

In the example shown in Fig. 3, it is assumed that the PCM digital signal S_{PCM} outputted from the player unit 10 is made up of the PCM serial data, bit clock and word clock, and these signals are supplied to the serial to parallel or S/P converter 201 from the first to third signal input terminals 21a, 21b, 21c of the pitch conversion processor section 21.

25 The end signal S_{END} from the player unit 10 is supplied to a reset terminal of an up/down counter 223 of the pitch ratio control section 22 via a fourth signal input terminal 22d.

In the present embodiment, the pitch ratio control section 22 is provided with a preset counter 221 adapted for counting the clock pulses generated by the clock generator 220, and is adapted for supplying the output count pulses from the preset counter 221 to a readout address counter 208 of the pitch
30 conversion processor section 21. The output count pulses of the preset counter 221 are returned to its load terminal, in such a manner that the data given by a read only memory (ROM) 222 is preset each time an output count pulse is produced.

In the ROM 222, the data corresponding to the aforementioned pitch ratio β is written in advance and the data may be read therefrom with the output count data of the up/down counter 223 as address data.
35 The up/down counter 223 is adapted to count up by one whenever a first switch 224 connected to its count-up terminal is closed and to count down by one whenever a second switch 225 connected to its count-down terminal is closed.

The preset counter 221 is so designed that the frequency f_p of the output count pulses is changed in accordance the preset data thereof and that, when the output count data of the up/down counter 223 are all
40 logical zero, the data read out from the ROM 222 are preset so that the output count pulses are outputted with the frequency f_p corresponding to $\beta=1$.

Thus the up/down counter 223 is reset by the aforementioned end signal S_{END} so that the output count pulses from the preset counter 221 are automatically set at the frequency f_p corresponding to the state of
45 $\beta=1$.

In the present embodiment, PCM serial data are introduced into the S/P converter 201 of the pitch conversion processor section 21 in synchronism with the bit clock and are latched at the rising edge of the word clock, in such a manner that the aforementioned PCM serial data is converted into word-unit PCM parallel data. The PCM parallel data obtained at the S/P converter 201 are divided into the right channel data and left channel data so as to be written in left-channel and right-channel random access memory
50 RAMs 202, 203, respectively.

The RAMs 202, 203 are adapted for effecting the above described pitch conversion and are designed for writing and reading the data under the control of a RAM controller 209. The respective PCM parallel data read out from these RAMs 202, 203 are supplied to zero-crossing detection circuit 210, as well as to a parallel to serial or P/S converter 206 via cross fading circuits 204, 205, so that the parallel data are
55 reconverted into the PCM serial data at the P/S converter 206 so as to be outputted from the first signal output terminal 21a.

It should be noted that the P/S converter 206 may perform its signal conversion operation under the timing signal supplied from a main controller 200 in such a manner that the PCM serial data are outputted

from the first signal output terminal 21A, the bit clock corresponding to the PCM parallel data is outputted from the second signal output terminal 21B and a wordclock is outputted from the third signal output 21C.

To the RAM controller 209, a write address WA generated at a write address counter 207 adapted for counting the word clock supplied to the third signal input terminal 21C and a read address RA generated at
 5 a read address counter 208 adapted for counting the output count pulses of the preset counter 221 of the aforementioned pitch ratio control section 22 are supplied.

It should be noted that the word clock has the aforementioned reproducing sampling frequency f_s and that the read-out address counter 208 is constructed as a preset counter whose preset value can be changed under the instructions of the main controller 200.

10 When not reset by the end signal S_{END} from the player unit 10, the pitch ratio control section 22 may be so designed that, as shown in Fig. 4, a variable oscillator 220' is adapted for oscillating at the aforementioned frequency f_p shown in the aforementioned equation (3) and the oscillating frequency f_p is changed by pitch ratio controller 221'.

The data write/read operation to and from the RAMs 202, 203 is controlled in the following manner by
 15 the RAM controller 209.

Assumed that the sampling frequency of the reproduced PCM digital signals S_{PCM} introduced into the pitch conversion unit 20 is f_s and that the sampling frequency of the output signals supplied from the pitch conversion unit 20 is f_p , the input signal is sequentially written into RAMs 202, 203 in accordance with the write clock of the frequency f_s , and the output signal is sequentially read out from the RAMs 202, 203 in
 20 accordance with the read-out clock of the frequency f_p . That is, the waveform of the signal read out at a speed different from that at which it is written into the RAMs 201, 203 is compressed or expanded on the time base so that the pitch conversion ratio becomes f_p/f_s .

It should be noted that the address space on the RAMs 201, 203 can be visualized as a loop as shown in Fig. 5 by connecting the maximum address to the minimum address, with the write address WA and the
 25 read address RA travelling on the loop of the address space at speeds corresponding to f_s and f_p , respectively. The address difference (WA-RA) between the write address WA and the read address RA corresponds to the delay time T_D of the output signal from the input signal.

Assuming that the pitch conversion ratio f_p/f_s is larger than unity, or $f_p < f_s$, the read address RA travels on the address space on the RAM shown in Fig. 5 at a speed faster than the write address WA. The result
 30 is that the address difference (WA-RA) corresponding to the aforementioned signal delay time T_D is decreased with the lapse of time, and becomes minimum (about zero) when RA is about to overtake WA on the contrary becomes equal to the total capacity of the RAM when RA has just passed WA. When the maximum delay time corresponding to the total RAM capacity is expressed as $T_{D_{MAX}}$, the delay time T_D of the output signal from the input signal is changed as shown at in Fig. 6-A.

Referring to Fig. 6, the read address RA overtakes the write address WA right before time t_1 and the delay time T_D is equal to the maximum value $T_{D_{MAX}}$ right after time t_1 . As RA approaches WA with the lapse of time, the delay time T_D is decreased gradually. At (or right before) time t_2 , that is, after lapse of the predetermined time T_F , RA overtakes WA again so that the delay time T_D becomes minimum (about zero).
 40 Thus the input signal (Fig. 6-B) of time interval from the point p_1 preceding the time t_1 by the above time interval $T_{D_{MAX}}$ to the point p_2 at the time t_2 is compressed in a time interval T_F so as to give an output signal (Fig. 6-C) of time interval from the point q_1 at the time t_1 to the point q_2 at the time t_2 . That is, the contents at the point q_1 of the delayed output signal shown in Fig. 6-C are those at the point q_1 of the input signal shown in Fig. 6-B preceding the time t_1 of the input signal by $T_{D_{MAX}}$ because the delay time at this time is equal to $T_{D_{MAX}}$. The delay time becomes less with the lapse of time in such a manner that the delay
 45 time becomes zero at (or right before) time t_2 which is later by T_F and the contents at the point p_2 of the input signal are precisely those at the point q_2 of the output signal. At the time t_2 , the delay time is changed discontinuously from the minimum value 0 to the maximum value $T_{D_{MAX}}$. The contents of the output signal (Fig. 6-C) at the point q_3 right after time t_2 is precisely that of the input signal (Fig. 6-B) at the point p_3 which precedes the time t_2 by $T_{D_{MAX}}$. In the similar manner, the contents of the input signal (Fig. 6-B) during the time $(T_F + T_{D_{MAX}})$ from the point p_3 to the point p_4 become those of the output signal (Fig. 6-C) during the time T_F from the point q_3 to the point q_4 by time base compression, while the contents of the input signal from the point p_5 to the point p_6 become those of the output signal from the point q_5 to the point q_6 et seq, in such a manner that a time base compression is effected by a factor of f_p/f_s between the input and output signals. At this time, the contents of the output signals (Fig. 6-C) at the times $t_1, t_2, t_3, \dots$
 55 are discontinuous and, in addition, in the vicinity of those times $t_1, t_2, t_3, \dots$, the contents of the input signal (Fig. 6-B) for the respective time intervals $T_{D_{MAX}}$ are repeatedly outputted at the points $p_1, p_2, p_3, \dots$.

In the present concrete example, in order to prevent the occurrence of click noises etc. due to the discontinuous or overlapped signal portions, zero-crossing detection is made by a zero-crossing detection

circuit 210 through making use of the MSBs of the PCM parallel data read out from the RAMs 202, 203 and the detecting output signal is supplied to the main controller 200. The preset values of the read-out address counter 208 are changed on the basis of the detecting output signal so that the waveform of the reproduced analog audio signals becomes continuous at the zero-crossing points as shown in Fig. 7 or Fig 8. If the zero-crossing detection is done for the low-frequency components of the original signal, more desirable reproduced waveforms are achieved on the sense of hearing. The main controller 200 is adapted to determine the cross-fade timing on the basis of the zero-crossing detection output and to activate the cross-fading circuits 204, 205 by means of a cross-fading controller 211.

Fig. 7 shows the operation for the case $\alpha > 1$, $\beta = 1$ in the present embodiment. When the original signal waveform as shown in Fig. 7-A is fast reproduced with a magnifying factor α in the player unit 10, the reproduced analog waveform corresponding to the PCM digital signal derived from the player unit 10 undergoes a time base compression as shown in Fig. 7-B. The pitch conversion unit 20 performs a pitch conversion of the PCM digital data with a pitch ratio β for forming a reproduced PCM digital data corresponding to the reproduced analog signal having the same sound pitch as that of the original signal waveform as shown in Fig. 7-C. In the present pitch conversion unit 20, the PCM digital data are partially omitted by changing the preset value of the readout address counter 208 according to the zero-crossing detection so as to assure the continuity of the reproduced analog signal waveform. Similarly, the operation for the cases $0 < \alpha < 1$ and $\beta = 1$ is shown in Figs. 8A, 8B, and 8C.

In the above embodiment, the end signal S_{END} is generated at the player unit 10 on the basis of the P-channel data of the users' bits and the up/down counter 223 of the pitch ratio control section 22 is reset by the end signal S_{END} . However, the end signal S_{END} may also be generated from the Q-channel data of the users' bits. In the existing compact disk player, users' bits can be taken out at the accessory port. Since the data indicating the tune number is also included in the Q-channel data, the data can be used for automatically setting the pitch ratio β in dependence upon the tune reproduced by the player unit 10, in case that a RAM be provided in the pitch ratio control section 22 and the data as a function of the tune to be reproduced be previously written in the RAM so as to read out the preset data corresponding to the arbitrary pitch ratio β from the ROM 222.

Although the present invention is applied to the compact disk player in the above described embodiment, the present invention is not limited to the above embodiment and can also be applied to the analog player or to the reproducing systems for other digital audio signals such as digital audio tape recorders. In the case of the analog player, the pitch ratio can be automatically set by the music interval signal obtained by the music interval detection of the reproduced audio signal.

From the foregoing it is seen that the present invention provides an apparatus for reproducing audio signal in which desired pitch conversion can be effected at the pitch conversion unit without requiring information indicating the ratio of change of the reproducing speed at the player unit, and in which variable independent control of the pitch and reproducing speed of the reproduced audio signal can be made so as to be suitably used in connection with so-called "kara-oke" reproduction.

Also the apparatus for reproducing audio signal suitable for "kara-oke" reproduction is provided according to the present invention because the preset pitch ratio can be automatically set for each tune of the reproduced signal for improving the operability of the apparatus.

Claims

1. An apparatus for reproducing an audio signal comprising:

a reproducing unit (10) for reproducing a data signal including audio signal data at an arbitrary α -times of a predetermined speed from a medium (11) on which the audio signal data is previously recorded at the predetermined speed and at a predetermined sampling frequency (F_s);

a pitch conversion unit (20) having a memory (202, 203) into which the audio signal data obtained from said reproducing unit (10) are written according to a write clock signal corresponding to the reproducing speed and from which the audio signal data are read out according to a read clock signal corresponding to an arbitrary β -times of the predetermined speed;

wherein α and β are relatively changeable; characterised by

means (13) for producing from the reproduced data signal (S_{PB}) the write clock signal having a reproducing sampling frequency (F_s) equal to α -times the predetermined sampling frequency; and

means (22) for producing the read clock signal having a frequency $f_p (= \beta F_s)$ which is β -times of the predetermined sampling frequency F_s .

2. An apparatus according to claim 1, wherein the audio signal data (S_{PCM}) are digital audio signal data



circuit 210 through making use of the MSBs of the PCM parallel data read out from the RAMs 202, 203 and the detecting output signal is supplied to the main controller 200. The preset values of the read-out address counter 208 are changed on the basis of the detecting output signal so that the waveform of the reproduced analog audio signals becomes continuous at the zero-crossing points as shown in Fig. 7 or Fig 8. If the zero-crossing detection is done for the low-frequency components of the original signal, more desirable reproduced waveforms are achieved on the sense of hearing. The main controller 200 is adapted to determine the cross-fade timing on the basis of the zero-crossing detection output and to activate the cross-fading circuits 204, 205 by means of a cross-fading controller 211.

Fig. 7 shows the operation for the case $\alpha > 1$, $\beta = 1$ in the present embodiment. When the original signal waveform as shown in Fig. 7-A is fast reproduced with a magnifying factor α in the player unit 10, the reproduced analog waveform corresponding to the PCM digital signal derived from the player unit 10 undergoes a time base compression as shown in Fig. 7-B. The pitch conversion unit 20 performs a pitch conversion of the PCM digital data with a pitch ratio β for forming a reproduced PCM digital data corresponding to the reproduced analog signal having the same sound pitch as that of the original signal waveform as shown in Fig. 7-C. In the present pitch conversion unit 20, the PCM digital data are partially omitted by changing the preset value of the readout address counter 208 according to the zero-crossing detection so as to assure the continuity of the reproduced analog signal waveform. Similarly, the operation for the cases $0 < \alpha < 1$ and $\beta = 1$ is shown in Figs. 8A, 8B, and 8C.

In the above embodiment, the end signal S_{END} is generated at the player unit 10 on the basis of the P-channel data of the users' bits and the up/down counter 223 of the pitch ratio control section 22 is reset by the end signal S_{END} . However, the end signal S_{END} may also be generated from the Q-channel data of the users' bits. In the existing compact disk player, users' bits can be taken out at the accessory port. Since the data indicating the tune number is also included in the Q-channel data, the data can be used for automatically setting the pitch ratio β in dependence upon the tune reproduced by the player unit 10, in case that a RAM be provided in the pitch ratio control section 22 and the data as a function of the tune to be reproduced be previously written in the RAM so as to read out the preset data corresponding to the arbitrary pitch ratio β from the ROM 222.

Although the present invention is applied to the compact disk player in the above described embodiment, the present invention is not limited to the above embodiment and can also be applied to the analog player or to the reproducing systems for other digital audio signals such as digital audio tape recorders. In the case of the analog player, the pitch ratio can be automatically set by the music interval signal obtained by the music interval detection of the reproduced audio signal.

From the foregoing it is seen that the present invention provides an apparatus for reproducing audio signal in which desired pitch conversion can be effected at the pitch conversion unit without requiring information indicating the ratio of change of the reproducing speed at the player unit, and in which variable independent control of the pitch and reproducing speed of the reproduced audio signal can be made so as to be suitably used in connection with so-called "kara-oke" reproduction.

Also the apparatus for reproducing audio signal suitable for "kara-oke" reproduction is provided according to the present invention because the preset pitch ratio can be automatically set for each tune of the reproduced signal for improving the operability of the apparatus.

Claims

1. An apparatus for reproducing an audio signal comprising:

a reproducing unit (10) for reproducing a data signal including audio signal data at an arbitrary α -times of a predetermined speed from a medium (11) on which the audio signal data is previously recorded at the predetermined speed and at a predetermined sampling frequency (F_s);

a pitch conversion unit (20) having a memory (202, 203) into which the audio signal data obtained from said reproducing unit (10) are written according to a write clock signal corresponding to the reproducing speed and from which the audio signal data are read out according to a read clock signal corresponding to an arbitrary β -times of the predetermined speed;

wherein α and β are relatively changeable; characterised by

means (13) for producing from the reproduced data signal (S_{PB}) the write clock signal having a reproducing sampling frequency (F_s) equal to α -times the predetermined sampling frequency; and

means (22) for producing the read clock signal having a frequency $f_p (= \beta F_s)$ which is β -times of the predetermined sampling frequency F_s .

2. An apparatus according to claim 1, wherein the audio signal data (S_{PCM}) are digital audio signal data



formed by pulse code modulating an analog audio signal and further comprising a digital to analog converter (30) for converting the digital audio signal data from said pitch conversion unit (20) to analog so as to obtain a reproduced analog audio signal.

- 5 3. An apparatus according to claim 1 or 2, wherein said pitch conversion unit (20) includes a variable oscillator (22) and the read clock signal is generated according to and corresponding to the output of said variable oscillator (22) so that the pitch conversion of the reproduced audio signal corresponding to the ratio of the oscillator frequency to the predetermined sampling frequency ($f_p:F_s$) is effected independently of the reproducing speed of said reproducing unit (10).
- 10 4. An apparatus according to claim 3, wherein said variable oscillator (22) is constituted by a digital oscillator.
- 15 5. An apparatus according to claim 1, 2, 3 or 4, wherein said pitch conversion unit (20) includes a pitch ratio control section (22) for automatically setting the pitch conversion ratio thereof to a preset value on the basis of a signal (S_{END}) indicating the starting or end of the reproduced audio signal.
- 20 6. An apparatus according to any one of the preceding claims, wherein said pitch conversion unit (20) comprises means (204, 205, 211) for separating low-frequency components of an audio signal represented by the audio signal data, and means (210) for detecting zero-crossing points of the audio signal, signal segments being connected at the low frequency zero-crossing point.

Revendications

- 25 1. Appareil permettant de reproduire un signal audio, comprenant :
une unité de reproduction (10) servant à reproduire un signal de données comportant des données de signal audio à une vitesse valant un nombre arbitraire α de fois une vitesse prédéterminée à partir d'un support (11) sur lequel les données de signal audio ont été antérieurement enregistrées avec la vitesse prédéterminée et à une fréquence d'échantillonnage prédéterminée (F_s);
30 une unité (20) de conversion de hauteur de son possédant une mémoire (202, 203) dans laquelle les données de signal audio obtenues de ladite unité de reproduction (10) sont écrites en fonction d'un signal d'horloge d'écriture correspondant à la vitesse de reproduction et dans laquelle les données de signal audio sont lues en fonction d'un signal d'horloge de lecture correspondant à un nombre arbitraire β de fois la vitesse prédéterminée ;
35 où α et β sont relativement variables ; caractérisé par :
un moyen (13) servant à produire, à partir du signal de données reproduit (S_{PB}), un signal d'horloge d'écriture possédant une fréquence d'échantillonnage de reproduction f_s ($=\alpha F_s$) égale à un nombre α de fois la fréquence d'échantillonnage prédéterminée ; et
40 un moyen (22) servant à produire un signal d'horloge de lecture possédant une fréquence f_p ($=\beta F_s$) qui vaut un nombre β de fois la fréquence d'échantillonnage prédéterminée F_s .
2. Appareil selon la revendication 1, où les données de signal audio (S_{PCM}) sont des données de signal audio numériques formées par modulation, par impulsions codées, d'un signal audio analogique, et comprenant en outre un convertisseur numérique-analogique (30) servant à convertir les données de signal audio numériques venant de ladite unité de conversion de hauteur de son (20) sous forme analogique de façon que soit obtenu un signal audio analogique reproduit.
- 45 3. Appareil selon la revendication 1 ou 2, où ladite unité de conversion de hauteur de son (20) comporte un oscillateur variable (22) et le signal d'horloge de lecture est produit en fonction du signal de sortie dudit oscillateur variable (22) et en correspondance avec celui-ci de façon qu'une conversion de la hauteur de son du signal audio reproduit qui correspond au rapport de la fréquence d'oscillateur à la fréquence d'échantillonnage prédéterminée ($f_p:F_s$) soit effectuée indépendamment de la vitesse de reproduction de ladite unité de reproduction (10).
- 50 4. Appareil selon la revendication 3, où ledit oscillateur variable (22) est constitué par un oscillateur numérique.
- 55 5. Appareil selon la revendication 1, 2, 3 ou 4, où ladite unité de conversion de hauteur de son (20)



comporte une partie (22) de commande de rapport de hauteur de son servant à fixer automatiquement son rapport de conversion de hauteur de son à une valeur préfixée sur la base d'un signal (S_{END}) indiquant le début ou la fin du signal audio reproduit.

- 5 6. Appareil selon l'une quelconque des revendications précédentes, où ladite unité de conversion de hauteur de son (20) comprend un moyen (204, 205, 211) servant à séparer les composantes de basse fréquence d'un signal audio représenté par les données de signal audio, et un moyen (210) servant à détecter les points de passage par zéro du signal audio, les segments de signal étant connectés au point de passage par zéro de basse fréquence.

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Patentansprüche

1. Vorrichtung zur Wiedergabe eines Audiosignals
mit einer Wiedergabeeinheit (10) für die mit dem frei wählbaren α -fachen Wert einer vorbestimmten Geschwindigkeit erfolgende Wiedergabe eines Audiosignaldaten enthaltenden Datensignals von
15 einem Medium (11) auf dem die Audiosignaldaten zuvor mit der vorbestimmten Geschwindigkeit und einer vorbestimmten Abtastfrequenz (F_a) aufgezeichnet wurden,
sowie mit einer Tonhöhen-Umwandlungseinheit (20) mit einem Speicher (202, 203), in den die von der Wiedergabeeinheit (10) gewonnenen Audiosignaldaten nach Maßgabe eines der Wiedergabegeschwindigkeit entsprechenden Schreibtaktsignals eingeschrieben werden und aus dem die Audiosignaldaten nach Maßgabe eines einem frei wählbaren β -fachen Wert der vorbestimmten Geschwindigkeit entsprechenden Lesetaktsignals ausgelesen werden,
20 wobei α und β relativ veränderbar sind,
gekennzeichnet durch
25 Mittel (13) zur Erzeugung des Schreibtaktsignals aus dem wiedergegebenen Datensignal (S_{PB}), wobei das Schreibtaktsignal eine Wiedergabe-Abtastfrequenz (F_a) hat, die gleich dem α -fachen Wert der vorbestimmten Abtastfrequenz ist, und
Mittel (25) zur Erzeugung des Lesetaktsignals mit einer Frequenz (f_p) ($= \beta F_a$), die gleich dem β -fachen der vorbestimmten Abtastfrequenz (F_a) ist.
- 30 2. Vorrichtung nach Anspruch 1, bei der die Audiosignaldaten (S_{PCM}) durch Pulsmodulation eines analogen Audiosignals gewonnene digitale Audiosignaldaten sind und bei der ferner ein Digital/Analog-Wandler (30) zur Digital/Analog-Wandlung der aus der Tonhöhen-Umwandlungseinheit (20) kommenden digitalen Audiosignaldaten und zur Gewinnung eines analogen Wiedergabe-Audiosignals vorgesehen ist.
- 35 3. Vorrichtung nach Anspruch 1 oder 2, bei der die Tonhöhen-Umwandlungseinheit (20) einen variablen Oszillator (22) aufweist und das Lesetaktsignal in Übereinstimmung mit und entsprechend dem Ausgangssignal dieses variablen Oszillators (22) erzeugt wird, derart daß die dem Verhältnis (f_p/F_a) der Oszillatorfrequenz zu der vorbestimmten Abtastfrequenz entsprechende Tonhöhen-Umwandlung des wiedergegebenen Audiosignals unabhängig von der Wiedergabegeschwindigkeit der Wiedergabeeinheit (10) durchgeführt wird.
- 40 4. Vorrichtung nach Anspruch 3, bei der der variable Oszillator (22) von einem digitalen Oszillator gebildet ist.
- 45 5. Vorrichtung nach Anspruch 1, 2, 3 oder 4, bei der die Tonhöhen-Umwandlungseinheit (20) ein Steuerteil (22) zur Steuerung des Tonhöhen-Verhältnisses aufweist, mit deren Hilfe ihr Tonhöhen-Umwandlungs-Verhältnis auf der Basis eines Signals (S_{END}), das den Start oder das Ende das wiedergegebenen Audio-signals angibt, automatisch auf einen vorbestimmten Wert einstellbar ist.
- 50 6. Vorrichtung nach einem der vorhergehenden Ansprüche, bei der die Tonhöhen-Umwandlungseinheit (20) Mittel (204, 205, 211) zur Abtrennung von Niederfrequenzkomponenten des von den Audiosignaldaten repräsentierten Audiosignals aufweist sowie Mittel (210) zur Erfassung von Nulldurchgängen des Audiosignals, wobei an den Niederfrequenz-Nulldurchgängen Signalsegmente verbunden werden.
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