

HIGH SPEED SEARCHING

The present invention generally relates to tape searching, and is concerned particularly, although not  
5 exclusively with high speed searching of a digital audio tape recorder (hereinafter referred to as DAT).

In a known DAT system a servo circuit is employed to perform a tape searching function. Conventionally, the  
10 servo circuit is employed to perform a function of speed-variable play such as normal speed (X1), two-speed (X2), three-speed (X3), five-speed (X5), nine-speed (X9) and sixteen-speed (X16) play and high speed searching of one-hundred-speed (X100) and two-hundred-speed (X200).  
15 However, the demand for tape searching faster than the two-hundred-speed play has arisen, as the technique in the DAT system is advanced. Particularly, in order to read out data stored on a data-storage tape with higher speed, there arises a need to search the tape with a speed higher  
20 than the two-hundred-speed.

In the case where a tape searching faster than two-hundred-speed is enforced according to a known method it is very difficult to detect a start ID (identification) of  
25 each program written on the tape, while keeping the relative velocity between a head drum and the tape constant. In other words, if the velocity of the drum is corrected as shown in Figure 1, the relative velocity is found according to the following procedure.

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Hereinafter, the problems of the prior DAT system, which occur during fast tape searching will be explained assuming that the DAT system has a drum diameter of  $30\phi$ , a drum rotation of 2000rpm (in normal play), a tape

running speed of 8.15mm/sec and track pattern (still) slope of 6°22'.

When a fast forward (hereinafter called FF for short) search is made at two-hundred-speed (X200) play, the relative velocity  $V_r$  of drum is given as

$$V_r = X \cdot V_d \cdot \cos\theta - 200V_t \dots\dots\dots(1)$$

Wherein,  $X$  represents a magnification factor of the present drum speed against the normal drum speed,  $V_d$  normal speed of the drum and  $V_t$  normal tape running speed.

In order to obtain the magnification factor  $X$ , if the left term of Equation (1) is substituted by a normal drum speed, then

$$V_d \cdot \cos\theta - V_t = X \cdot V_d \cdot \cos\theta - 200V_t \dots\dots\dots(2)$$

From the above Equation (2), the magnification factor  $X$  can be obtained as follows:

$$X = 1 \pm \frac{199V_t}{V_d \cdot \cos\theta} \approx 1.52 \dots\dots\dots(3)$$

In Equation (2), it is noted that the number of drum rotations is 1.52 times that of the normal speed, which is 3040rpm, that of the normal speed, if the tape is searched at two-hundred-speed FF search mode.

Conversely, when a rewind (hereinafter, called RWD for short) search is made at two-hundred-speed (X200), the normal tape running speed  $V_t$  becomes negative number. Therefore, the number of drum rotations for keeping the relative

velocity  $V_r$  constant must be 960rpm upon the basis of the following Equations (4) and (5).

$$V_R = X \cdot V_d \cdot \cos\theta + 200V_t = 1 \dots\dots\dots(4)$$

$$X = 1 - \frac{201V_t}{V_d \cdot \cos\theta} \quad 0.2146$$

$$\approx 0.48 \quad \dots\dots\dots(5)$$

For a three-hundred-speed (X300) FF search, the magnification factor  $X$  must be  $X \approx 1.78$ . In the same way, the number of drum rotation must be about 3,560rpm with  $X \approx 1.78$  and, when a search is made at three-hundred-speed (X300) RWD, the number of drum rotation must be about 420 rpm with  $X \approx 0.2146$ .

Considering further this point, the performance of the drum motor is limited to a specific speed, as illustrated in Figure 2. That is to say, if the tape searching was made at or close the four-hundred-speed (X400) RWD mode, the drum would have to be rotated backwardly in theory. In practice, however, it is impossible for the drum to do so. It is also difficult to make a high speed search by correcting only the relative velocity of the drum in such a case, and problems arise as to how to contrive another method of searching the tape with high speed.

Therefore, specific embodiments of the present invention aim to provide an improved method of high speed searching for a desired tape portion in an digital audio tape recorder.

According to one aspect of the invention there is provided a method of searching a tape in a tape player, the method comprising the steps of identifying the present position of the tape, comparing this with information concerning a desired position of the tape, and in the event that the present position is not inside a tape region within which the desired position is located, automatically winding the tape at a speed greater than that of normal play and, when the present position is inside the tape region within which the desired position is located, gradually reducing the winding speed until a start ID of the desired program is found.

Information about the desired position of the tape may be obtained from stored information about the contents of the tape.

The information about the contents of the tape may be read into a microprocessor.

Preferably information about the contents of the tape includes information about the position of a program on the tape.

Identification of the present position of the tape may be obtained by comparing the extent to which the tape is wound onto a supply reel with the extent to which tape is wound onto a take-up reel of the tape player.

Preferably the extents to which tape is wound onto supply and take-up reels is found from operational signals of the supply and take-up reels respectively.

Preferably a user is able to select a desired program to be searched for.

In a preferred arrangement a user is able to select a tape speed at which the search is to be carried out.

5 A head of the tape player may be prevented from contact with the tape during at least part of the search.

Preferably information about the contents of the tape is read into the microprocessor from a portion of the tape.

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The method may comprise a method of searching a digital audio tape.

15 According to a further aspect of the present invention a tape searching circuit for use with a tape player, the tape searching circuit comprising a microprocessor and speed control means, the microprocessor being arranged, in use, to monitor the present position of the tape, compare the present position with information  
20 concerning a tape region within which a start ID of a desired program is located, and speed control means being arranged to control the speed of a reel motor of the tape player such that, in the event that the present position is not within the said tape region, the tape is  
25 automatically wound, under microprocessor control, at a speed greater than that of normal play and, when the present position is within the said tape region, the winding speed, is gradually reduced until the start ID of the desired program is found.

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In a preferred arrangement, if the present position of the tape is not within the said tape region the reel-motor is made to operate at an increased speed compared to a normal play speed.

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Information about a desired position of the tape may be obtained from information read into the microprocessor about the contents of the tape.

- 5        Preferably information about the contents of the tape comprises information about the position on the tape of a program on the tape.

10       In a preferred arrangement, the microprocessor monitors the present position of the tape by comparing the extent to which the tape is wound onto a supply reel of the tape player with the extent to which tape is wound onto a take-up reel of the tape player.

- 15       Preferably, the extent to which tape is wound onto supply and take-up reels of the tape player may be found by the microprocessor monitoring operational signals from the supply reel and the take-up reel respectively.

- 20       Preferably the circuit may include a microprocessor which microprocessor reads information about the contents of the tape, which information is stored at the beginning of the tape, and generates a predetermined control signal according to a search signal input by the user and a  
25       program number signal input by a user, a sequencer which chooses a motor driving frequency and checks whether a phase locked loop circuit is locked or not in order to transmit a signal to the microprocessor, on the basis of the mean value of a take-up reel signal and a supply reel  
30       signal, a period selector which chooses a main count clock, which clock counts the period of the signal generated from a motor and the corresponding frequency of a pulse width modulation signal, a speed detecting/controlling circuit which detects the speed of  
35       the reel motor and counts the period of the signal from

the motor to generate a phase locked loop locking signal, a pulse width modulator which modulates the pulse width of the output of the speed detecting and controlling circuits under the control of the period selector, a low pass filter which provides the motor with the low pass filtered output, thereby to control the motor with a predetermined speed.

The invention also includes a tape player when used with a circuit or a method substantially as herein described with reference to the accompanying drawings.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings, in which:

Figure 1 is an illustration of drum motor velocity correction;

Figure 2 is a graph for showing the relationship between the rate of drum rotation and tape searching velocity;

Figure 3 is a block diagram for implementing a method according to one embodiment of the present invention.

Figure 4 is a flowchart representing the method of Figure 3.

Figures 5A-5E are illustrations of tape running time sensing by the detection of Frequency Generator (FG) signal; and

Figure 6 is an illustration of TOC (table of contents) information.

Referring particularly to Figure 3, there is shown a block diagram showing a method according to one embodiment of the invention. First, a microcomputer 10 reads out Table-of-contents (TOC) information (stored at the beginning of a tape) and generates a predetermined control signal according to a selection signal of a specific high-speed search mode and a program number selection signal (positional information) which are chosen by a user. A sequencer 20 chooses a motor driving frequency and checks whether a PLL (phase locked loop) circuit is locked or not in order to transmit a FG (frequency generator) signal to the microprocessor 10, on the basis of the mean value of a take-up reel FG signal and a supply reel FG signal. A period selector 30 chooses a main count clock which counts the FG period generated from a motor 80 and the corresponding frequency of a PWM (pulse width modulation) signal. Then, a speed detecting/controlling circuit 40 detects the speed of the reel motor 80 and counts the FG period to decode it and generates a PLL locking signal after decoding the FG signal. A pulse width modulator (PWM) 50 modulates the pulse width of the output of the speed detecting and controlling circuit 40 under the control of said period selector 30. The output of the pulse width modulator 50 is low-pass-filtered in a low pass filter 60 to provide the motor 80 with the low-pass-filtered output, thereby controlling the motor 80 with a predetermined speed.

The operation of the invention will now be described in detail according to the configuration described above. A flowchart showing a method of carrying out features of the embodiment, the sensing illustration of the tape

searching by the FG signal, and the TOC information therefor are shown in Figures 4 through 6.

Referring both to Figures 3 and 4, the microcomputer 10 receives a signal corresponding to the three-hundred-speed (X300) FF search mode selected by the user, in a stage 100. The microcomputer 10 then receives a program number (or, tape positional information) desired by the user in a stage 110. Thereafter, the microcomputer 10 checks in a stage 120 if the TOC information is readable under the present operating condition.

If the present condition is judged able to read the TOC information as a result of such checking stage 120, the microcomputer 10 proceeds to a stage 130 to read out the TOC information from a TOC circuit 70.

As the TOC circuit 70 contains information about the contents of the tape, time information for the position of the tape at a desired part can be read out. In the embodiment, it is assumed that the TOC information is like that shown in Figure 6.

A present position and time are counted from the FG period value decoded, in a stage 140. In other words, the amount of tape wound onto the take-up reel against the amount of tape wound onto the supply reel is obtained, if the ratio of a value which is decoded by counting the FG periods of both take-up and supply reels is known.

In the case of a tape the total running length of which is 120 minutes, for example, if the amount of tape wound onto the take-up reel is  $1/4$  of the amount of tape in minutes wound onto the supply reel, the present position of the tape is  $120 \times (1/4) = 30$ . It means that

the tape is at the point which corresponds to 30 minutes of the total 120 minutes. As the ratio of  $T_s/T_t$  (where  $T_s$  is tape wound onto the supply reel and  $T_t$  is the time value of the tape wound on the take-up reel) undergoes a continuous change according to the condition where the tape is wound onto the reels, it is used for controlling the searching speed. Although it has a constant value  $K$  as  $T_s + T_t = K$ , the constant value  $K$  is different for different speed magnification. In the case of one-hundred-speed (X100) play, the constant value  $K$  is half the constant value  $K$  during two-hundred-speed (X200), i.e.,  $(1/2)K$ .

However, as the ratio of  $T_s/T_t$  represents the amount (time) of tape which is wound onto the reels regardless of how fast the tape is running; the tape state (position) can be found from the ratio of  $T_s/T_t$ .

When the microcomputer 10 senses how fast a search is to be made, it designates the constant value  $K$  corresponding thereto and drives the reel motor 80 so as to take the amount of tape in the ratio of  $T_s/T_t$  within the constant value  $K$ . At this moment, the sequencer 20 drives the reel motor 80 by the constant value  $K$  determined according to each high-speed mode. Based on the constant  $K$ , the frequency of the main clock pulse required at the pulse width modulator 50 is determined, the clock pulse being used for controlling the power provided to the reel motor so as to control speed of the reel motor 80. The pulse width is varied at the pulse width modulator 50 according to the FG signal fed-back from the reel motor 80. Further, the sequencer 20 senses if the PLL is locked and sends a decoded FG period value to the microcomputer 10.

The period selector 30 determines the frequency of a main counter clock which counts the FG period and a corresponding PWM reference clock. The speed detecting/controlling circuit 40 which is under the control of the period selector 30 detects the speed of reel motor 80 in order to count the FG period, to decode it and then to generate PLL locking signal.

Thus, the reel motor 80 is controlled so as to take the amount of tape which will be wound onto both reels to the corresponding time position by confirming time information for a desired position from the TOC information given in Figure 6.

After the stage 140, the reel motor 80 is driven at three-hundred-speed (X300) search in a stage 150 and it is ascertained in the stage 160 if the amount of tape wound onto the reels is at the value of the desired tape portion. If the amount is not at the value of the desired tape portion, it is looped to the stage 140. If the stage 160 is judged as the value of the desired tape portion, the microcomputer 10 proceeds to a stage 170 to gradually make a slow, precise search from X200, X100, X16, X9, X5, X3 to X2 speed. The gradually slow, precise search is made as stated above from the region of the desired point, because it is unable for the tape to stop abruptly and correctly at the desired point due to the tape inertia.

After the stage 170 is performed, a start ID is detected and a high-speed search operation is come to an end in a stage 180.

As the TOC information is written in the front part of tape, the TOC information of tape becomes unknown if the system is reset by being cut off from power supply or

replaced by another tape during the operation. As the tape wound around the middle contains the TOC information at the beginning portion, it must be read again beginning with start point. Therefore, in the case of the stage 5 170, the microcomputer 10 may become unable to read the TOC information. In such a case, X200 speed search will be made when proceeding to the stage 180.

What should be taken into consideration in the case 10 where such a method as stated above is used is that the tape is brought into contact with the drum when a search is made at X300 or X400 speed search or at a speed faster than those in a condition where the tape is loaded and that this may have an undesirable influence on the head 15 and/or tape.

Accordingly, it is desirable to draw the drum backward a little in order that it may not be brought into contact with the tape, by the action of a suitable 20 instrumental mechanism in the case where a search is made, for example, at more than X200 speed and to bring the drum into contact with the tape when a search is made at less than X200 speed search. Such a process can be implemented by the control of the microcomputer and by a suitable 25 instrumental mechanism.

As described hereinbefore, the present invention is convenient in that it finds out a desired program written in the tape regardless of the relative velocity of the 30 drum even in a search made at more than X200 speed, by searching the digital audio tape by means of TOC and FG period.

**CLAIMS:**

1. A method of searching a tape in a tape player, the method comprising the steps of identifying the present position of the tape, comparing this with information concerning a desired position of the tape, and in the event that the present position is not inside a tape region within which the desired position is located, automatically winding the tape at a speed greater than that of normal play and, when the present position is inside the tape region within which the desired position is located, gradually reducing the winding speed until a start ID of the desired program is found.
2. A method according to Claim 1 wherein information about the desired position of the tape is obtained from stored information about the contents of the tape.
3. A method according to Claim 2, wherein information about the contents of the tape is read into a microprocessor.
4. A method according to Claims 2 or 3 wherein, information about the contents of the tape includes information about the position of a program on the tape.
5. A method according to any of the preceding claims wherein identification of the present position of the tape is obtained by comparing the extent to which the tape is wound onto a supply reel with the extent to which tape is wound onto a take-up reel of the tape player.
6. A method according to Claim 5, wherein the extents to which tape is wound onto supply and take-up reels is found



from operational signals of the supply and take-up reels respectively.

5 7. A method according to any of the preceding claims wherein, a user is able to select a desired program to be searched for.

10 8. A method according to any of the preceding claims wherein, a user is able to select a tape speed at which the search is to be carried out.

15 9. A method according to any of the preceding claims wherein, a head of the tape player is prevented from contact with the tape during at least part of the search.

10. A method according to Claim 3 wherein, the information about the contents of the tape is read into the microprocessor from a portion of the tape.

20 11. A method according to any of the preceding claims which comprises a method of searching a digital audio tape.

25 12. A tape searching circuit for use with a tape player, the tape searching circuit comprising a microprocessor and speed control means, the microprocessor being arranged, in use, to monitor the present position of the tape, compare the present position with information concerning a tape region within which a start ID of a desired program is  
30 located, and speed control means being arranged to control the speed of a reel motor of the tape player such that, in the event that the present position is not within the said tape region, the tape is automatically wound, under microprocessor control, at a speed greater than that of  
35 normal play and, when the present position is within the



said tape regions, the winding speed is gradually reduced until the start ID of the desired program is found.

13. A circuit according to Claim 12 wherein if the present position of the tape is not within the said tape region, the reel-motor is made to operate at an increased speed compared to the normal play speed.

14. A circuit according to Claim 12 or Claim 13 wherein information about a desired position of the tape is obtained from information read into the microprocessor about the contents of the tape.

15. A circuit according to Claim 14 wherein the information about the contents of the tape comprises information concerning the position on tape of the start ID of the desired program.

16. A circuit according to any of claims 12 to 15 wherein the microprocessor monitors the present position of the tape by comparing the extent to which the tape is wound onto a supply reel of the tape player with the extent to which tape is wound onto a take-up reel of the tape player.

17. A circuit according to Claim 16 wherein the extent to which tape is wound onto supply and take-up reels of the tape player is found by the microprocessor monitoring operational signals from the supply reel and the take-up reel respectively.

18. A circuit according to any of the Claims 12 to 18 wherein the microprocessor reads information about the contents of the tape, which information is stored at the beginning of the tape, and generates a predetermined



control signal according to a search signal input by a user and a program number signal input by the user, a sequencer which chooses a motor driving frequency and checks whether a phase locked loop circuit is locked or not in order to transmit a signal to the microprocessor, on the basis of the mean value of a take-up reel signal and a supply reel signal, a period selector which chooses a main count clock, which clock counts the period of the signal generated from a motor and the corresponding frequency of a pulse width modulation signal, a speed detecting/controlling circuit which detects the speed of the reel motor and counts the period of the signal from the motor to generate a phase locked loop locking signal, a pulse width modulator which modulates the pulse width of the output of the speed detecting and controlling circuits under the control of the period selector, a low pass filter which provides the motor with the low pass filtered output, thereby to control the motor with a predetermined speed.

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19. A method substantially as herein described with reference to the accompanying drawings.

20. A circuit substantially as herein described with reference to the accompanying drawings.

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21. A tape player when used with a circuit or a method substantially as herein described with reference to the accompanying drawings.

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