

Arrangement for reproducing n digital signals from n adjacent tracks on a record carrier.

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The invention relates to an arrangement for reproducing n digital signals from n adjacent tracks on a record carrier, which arrangement comprises

- read means comprising n read heads, each having an output, for reading n information signals from the n tracks and supplying said information signals to the outputs,
- 5 - n detection means having inputs coupled to the outputs of the n read heads, for deriving n digital signals from the n information signals read from tracks and supplying said digital signals to outputs,
- n phase-locked loops having inputs coupled to the n outputs of the read heads, each phase-locked loop comprising a phase comparator having a first input coupled to
- 10 the input of the phase-locked loop, having a second input and having an output, a voltage-controlled oscillator having an input coupled to the output of the phase comparator and having an output for supplying a clock signal of a given frequency, which output is coupled to the second input of the phase comparator. Such arrangements are known, for example, in the form of magnetic-tape recorders of the SDAT type or
- 15 the DCC type.

These recorders are capable of reading magnetic tapes on which digital audio has been recorded in a plurality of longitudinal tracks. This enables music reproduction of substantially CD quality to be achieved. The magnetic-tape recorder of

20 the DCC type has come onto the market recently and is intended as a new digital cassette recorder standard to supersede the current Compact Cassette standard.

For the consumer market it has also been envisaged to provide such an apparatus for portable use and for use in car radios. This imposes additional requirements on the immunity of such apparatus to mechanical vibrations and shocks, in

25 order to guarantee audio reproduction of substantially CD quality.

It is an object of the invention to provide an arrangement having an improved immunity to vibrations and shocks.

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The arrangement is characterized in that the arrangement comprises a control signal generator for deriving from the n output signals of the phase comparators a control signal which is a measure of the deviation of the relative speed of transport of the record carrier with respect to the read means from the nominal relative speed of transport of the record carrier with respect to the read means, and for supplying said control signal to an output, and the arrangement further comprises means for applying the control signal to the inputs of the n voltage-controlled oscillators.

The invention is based on the recognition of the following fact. For the clock extraction during readout of an information signal from a track on the record carrier a phase-locked loop is used. Mechanical vibrations and shocks result in variations of the relative speed of a read head with respect to the track. The phase-locked loop should have a bandwidth narrow enough to be immune to the noise present in the input signal applied to the loop and, conversely, the bandwidth should be so large that the loop is still capable of following the speed variations of the tape. In practice, an optimum bandwidth for the loop is determined for which the loop operates correctly. Nevertheless, it is found that the loop frequently comes out of lock in the case of shocks. However, a more limited bandwidth of the phase-locked loop again means that it is more difficult to track the normal speed variations of the tape. In order to extend the lock-in range of a phase-locked loop it is then known *per se* to add a frequency control loop.

In accordance with the present invention the output signal of the phase comparator, for each of the n tracks, is now applied to a common frequency control loop. Further, it is assumed that the speed variations are the same for all the tracks. Averaging the summed n phase errors yields a control signal which is a measure of the variation of the relative speed of transport of the record carrier with respect to the read means. The control signal, which may be regarded as a frequency control signal, is subsequently applied to the voltage-controlled oscillators of all the phase-locked loops. Since the information from all the n tracks is used it is possible to derive such a control signal that the loop responds more rapidly to speed variations. The frequency control proposed here differs from the above-mentioned frequency controls known from the literature in that it is a common frequency control.

For deriving the control signal the arrangement may be characterized further in that the control signal generator comprises a signal combination unit having n

inputs for receiving the n output signals of the n phase comparators, and having an output coupled to the output of the control signal generator *via* an integrating element. In a further embodiment the arrangement may be characterized in that the control signal generator further comprises detection means having an input coupled to the output of the integrating element and having an output coupled to a control signal input of a controllable amplifier device, which controllable amplifier device is coupled between the output of the signal combination unit and the input of the integrating element.

By comparing in the detector the output signal of the detector with a threshold value and, when this threshold value is exceeded, applying to the controllable amplifier device a control signal to increase the gain the bandwidth of the frequency control loop is extended and a faster control is achieved.

Some embodiments of the invention will now be described in more detail, by way of example, with reference to the drawings. In the drawings

Figure 1 shows an embodiment of the arrangement, and

Figure 2 shows a modification of the control signal generator used in the embodiment shown in Figure 1.

Figure 1 shows an arrangement intended for reading a digital signal from n tracks $T_{a,1}$ to $T_{a,n}$ which extend adjacent one another in the longitudinal direction of a magnetic record carrier 20 in the form of a tape. Only one half of the record carrier is shown. The arrangement has read means comprising n read heads 14.1 to 14. n which derive an analog signal from the n tracks. The n analog signals are applied to an n -channel bit detector 11. The analog signals are sampled and converted into a binary signal under the influence of a clock signal of a clock frequency $m \cdot f_b$ applied to the bit detector 11 by a fixed oscillator 12.

A clock frequency to be used for bit detection is derived from each of the n digital signals. To this end the resulting digital signals are applied to a phase-locked loop, n such loops 13.1 to 13. n being provided. For each channel $ch\ i$ of the channels $ch\ 1$ to $ch\ n$ the corresponding digital signal is applied to a first input of the phase comparator. The output of the phase comparator 17. i is coupled to the control signal input of a voltage-controlled oscillator 21. i , if required *via* a loop filter 18. i . The oscillator 21. i may be constructed as a discrete time oscillator.



The output of the oscillator 21.i is coupled to a second input of the phase comparator 17.i.

In accordance with the invention there is also provided a control signal generator 22. The control signal generator 22 is adapted to derive from the n output
5 signals of the phase comparators 17.1 to 17.n and to supply to an output 24 a control signal which is measure of the deviation of the relative transport speed of the record carrier 20 with respect to the read means 14.1 to 14.n from the nominal relative transport speed of the record carrier 20 with respect to the read means. The arrangement further comprises means for applying the control signal to the input of the
10 n voltage-controlled oscillators 21.1 to 21.n. For this purpose these means comprise signal combination units 19.1 to 19.n. The signal combination units may be constructed as adders and have a first input coupled to the output 24 of the control signal generator 22, a second input coupled to the output of a loop filter 18.i, and an output coupled to the control signal input of the oscillator 21.i.

15 The control signal generator 22 comprises a signal combination unit 25 and an integrating element 26. The signal combination unit 25 has n inputs coupled to the outputs of the phase comparators 17.1 to 17.n. The output of the signal combination unit 25 is coupled to the input of the integrating element 26, which has an output coupled to the output of the control signal generator 22.

20 Figure 2 shows a modification 22' of the control signal generator 22. The control signal generator 22' in addition comprises a detector 30 and a controllable amplifier 31. The controllable amplifier 31 is arranged in the connection between the output of the signal combination unit 25 and the input of the integrating element 26. The detector 30 has an input coupled to the output of the integrating element 26. The
25 output of the detector 30 is coupled to a control signal input of the controllable amplifier 31 to control the gain factor of the amplifier 31 under the influence of the control signal. The detector 30 is adapted to detect whether the output signal of the integrating element 26 exceeds a given threshold value. If this value is exceeded this means that there is a certain frequency deviation which is to be eliminated more rapidly.
30 This is achieved by additionally amplifying the output signal of the signal combination unit 25, so that a frequency control signal of larger amplitude can be applied to the voltage-controlled oscillators.



The invention has the advantage that the bandwidth of the phase-locked loops 13.i can be comparatively small because speed variations of the record carrier are handled by the additional control system, which may be regarded as a frequency control system.

5 Moreover, since the generator 22 uses n times as many signal transitions to determine the control signal, the signal-to-noise ratio of the control signal is higher.

The detector 30 preferably has a hysteresis in the threshold value such that, after the threshold value has been exceeded and the gain factor of the amplifier 31 has been increased, the threshold value is set to a lower level. This prevents the output
10 signal of the integrating element 26 from oscillating, which would lead to an oscillation of the gain factor of the amplifier 31, the gain factor each time varying from a high to a low value.

The detector 30 preferably also has a delay such that, if the output signal of the integrating element 26 decreases below the threshold value, the gain factor of the
15 amplifier 31 is reduced with a delay. Changing over to the higher value upon detection that the output signal of the integrating element 26 exceeds the threshold value is effected more or less instantaneously.

It is obvious that various implementations of the arrangements described herein are possible. In this respect it is to be noted that not all the elements as indicated
20 in the circuits shown in Figure 1 or 2 should be provided n times (or $2n$ times). The functions which can be time-multiplexed for the n channels then in principle require one element, which then operates in time multiplex.

It is to be noted also that the control signal supplied to the output 24 of the frequency detector 22 can be used as a control signal for the direct control of the
25 tape-transport speed control system. This enables a rapidly operating transport-speed control to be realized.

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Claims:

1. An arrangement for reproducing n digital signals from n adjacent tracks on a record carrier, which arrangement comprises
 - read means comprising n read heads, each having an output, for reading n information signals from the n tracks and supplying said information signals to the outputs,
 - 5 - n detection means having inputs coupled to the outputs of the n read heads, for deriving n digital signals from the n information signals read from tracks and supplying said digital signals to outputs,
 - n phase-locked loops having inputs coupled to the n outputs of the read heads, each phase-locked loop comprising a phase comparator having a first input coupled to
 - 10 the input of the phase-locked loop, having a second input and having an output, a voltage-controlled oscillator having an input coupled to the output of the phase comparator and having an output for supplying a clock signal of a given frequency, which output is coupled to the second input of the phase comparator, characterized in that the arrangement comprises a control signal generator for deriving from the n output
 - 15 signals of the phase comparators a control signal which is a measure of the deviation of the relative speed of transport of the record carrier with respect to the read means from the nominal relative speed of transport of the record carrier with respect to the read means, and for supplying said control signal to an output, and the arrangement further comprises means for applying the control signal to the inputs of the n voltage-controlled
 - 20 oscillators.
2. An arrangement as claimed in Claim 1, characterized in that the control signal generator comprises a signal combination unit having n inputs for receiving the n output signals of the n phase comparators, and having an output coupled to the output of the control signal generator *via* an integrating element.
- 25 3. An arrangement as claimed in Claim 2, characterized in that the control signal generator further comprises detection means having an input coupled to the output of the integrating element and having an output coupled to a control signal input of a controllable amplifier device, which controllable amplifier device is coupled

between the output of the signal combination unit and the input of the integrating element.

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