The invention relates to a detector circuit for a tracking control loop which guides the light beam produced by an optical scanner along the data tracks of a recording medium, wherein the light beam scanning the items of data generates a HF signal and a tracking error signal and wherein it is checked as to whether the envelope of the HF signal falls below a first predetermined threshold value.

CD players, video disc players, DRAW-disc players or magneto-optic recording and reproducing devices are equipped for example with a tracking control loop and an optical scanning device.

The construction and method of operation of an optical scanning device, a so-called optical pick-up, are described in "Electronic Components & Applications", Vol. 6, No 4, 1984 on pages 209 - 215.

The light beam emitted by a laser diode is focused by means of lenses onto the compact disc and reflected from there onto a photo-detector. The items of data stored on the compact disc and the current values for the focusing and for the tracking control loop are obtained from the output signal of the photo-detector. In the said document, the deviation of the current value from the reference value for the focusing control loop is referred to as the "focusing error" whilst the expression "radial tracking error" is selected for the deviation of the current value from the reference value for the tracking control loop.

A coil, by means of whose magnetic field an objective lens can be moved along the optical axis, serves as a control member for the focusing control loop. The focusing control loop now ensures, by displacement of the objective lens, that the light beam emitted by the laser diode is always focused on the compact disc. The optical scanning device is displacable in a radial direction with reference to the compact disc by means of the tracking control loop which is often referred to as a radial drive. Thereby, the light beam can be guided onto the spiral-shaped data track of the compact disc.

In some devices, the radial drive is constructed from a so-called coarse and a so-called fine drive means. The coarse drive means is implemented for example as a screw by means of which the whole optical scanning device consisting of the laser diode, the lenses, the prismatic beam splitter and the photo-detector is radially displacable. In addition, the light beam can be displaced in the radial direction by the fine drive means or it can, for example, be deflected through a predetermined small angle. Consequently, the light beam can be moved a small distance - about 1 mm - along a radius of the compact disc by means of the fine drive means.

In order to achieve a perfect reproduction of the data, be it now e.g. picture and sound in a video disc player or merely the sound from a CD player or the data on a magneto-optic disc, in addition to an exact focusing of the light beam on the disc, a precise guidance along the data tracks of the disc is required.

In Fig. 1, there is shown the photo-detector PD of the optical scanning device of a CD player, in which three laser beams L1, L2 and L3 are focused on the compact disc. The laser beams L2 and L3 are the diffraction beams of +1 and -1 order. An optical scanning device of this type is referred to as a three-beam-pick-up in the aforementioned document because it works with three light beams.

Four square-shaped photodiodes A, B, C and D are so arranged in the photo-detector that they themselves form a square. A rectangular photodiode E is located in front of the square formed by the four photodiodes A, B, C and D; a further photodiode F is provided behind the square. The central laser beam L1, which is focused on the four photodiodes A, B, C and D, generates the data signal HF = AS + BS + CS + DS and the focusing error signal FE = (AS + CS) - (BS + DS). The two outer light beams L2 and L3, of which the front one L3 falls on the photodiode E and the rear one L2 on the photodiode F, produce the tracking error signal T = ES - FS. The photoelectric voltages of the diodes A, B, C, D, E and F are respectively referenced AS, BS, CS, DS, ES and FS.

In the Figure 1, the central light beam L1 exactly follows the middle of a track S. The tracking error signal TE has the value zero.

$$TE = ES - FS = 0.$$

If the central light beam deviates from the middle of a track S, the one diffraction beam moves more towards the middle of the track whilst the other diffraction beam shines on the intervening space between two tracks S. However, because the properties of reflection for a track and an intervening space are different, the one diffraction beam is reflected more strongly than the other.

In Figure 2, there is illustrated the case of the laser beams L1, L2 and L3 being displaced to the right of the track S. The tracking error signal adopts a negative value:

$$TE = ES - FS < 0.$$

The adjusting member of the tracking control loop now moves the optical scanning device to the left until such time as the tracking error signal TE becomes zero.

In the opposite case, when the laser beams are displaced to the left of the track, the tracking error signal is positive: TE = ES - FS > 0. The adjusting member of the tracking control loop now moves the optical scanning device to the right until such time as the tracking error signal TE becomes zero. This case is shown in Figure 3.

If the light beam L1 and the appertaining diffraction beams L2 and L3 cross several data tracks, the tracking error signal TE adopts the sinusoidal waveform shown in Figure 4.

A tracking control loop in which it is detected from the lower and upper envelope-curves of the HF signal whether the light beam is crossing data tracks, is known from the JP-OS 60 10429. If the light beam runs over a plurality of data tracks then the HF signal regularly collapses between two tracks.

In order to determine the number of tracks that are swept over by the light beam, one generates the curve corresponding to the envelope of the HF signal and converts it into a pulse-shaped signal which is supplied to the counting input of an up-down counter. The HF collapses are counted in this manner by the up-down counter.

In order to determine the direction in which the light beam is being moved, radially inwards or outwards, one requires a so-called directional logic which evaluates the phase displacement between the tracking error signal TE and the envelope of the HF signal.

A tracking control loop is known from the GB-A 2 073 543 in which it is checked as to whether the HF signal lies below a predetermined threshold value. If this is the case, then a positive or a negative voltage is applied to the adjusting means of the optical scanner which is reading the items of data in dependence on the prefix sign of the tracking error signal in order to guide it onto the correct data track.

However, because dust, dirt, fingerprints or scratches on a compact disc can also be the cause of a collapse in the HF signal, measures have to be taken in order to be able to distinguish one from another, the HF collapses caused by dirt or damage on the recording medium and such HF collapses as result from the light beam changing track.

A CD player is known from the EP-A 0 183 303 in which the engagement of the light spot with a data track of the compact disc, the so-called locking-in, results at the point of greatest eccentricity of the disc because the relative speed between the

light beam and the data track is at its lowest at the point of greatest eccentricity. In order to determine the number of data tracks that have been crossed by the light beam, the envelope of the HF signal is generated and compared with a threshold value. The comparison of the envelopes of the HF signal with the first threshold value yields a pulse-shaped signal. Each pulse of this pulse-shaped signal indicates a change of track.

In order to make the CD player more secure against so-called "drop-outs" - these are audible distortions in the reproduction of the sound due to a defective, scratched or dirty compact disc - the envelope of the HF signal can be compared with a second threshold value. A pulse is now generated from the envelope of the HF signal only when the envelope exceeds both the first and the second threshold values and if the drop-out detector of the CD player is not operational.

A CD player having a drop-out detector which evaluates the HF signal is known from the WO-A-88/09988.

Thus, the object of the invention is to develop a detector circuit in accordance with the first part of claim 1 in such a way that dirt or scratches on the recording medium can no longer simulate a change of track of the scanning light beam.

This object is achieved by the invention in that, the detector circuit only emits a signal, which indicates that the light beam scanning the items of data is departing from a data track, if the envelope of the HF signal lies below the first predetermined threshold value and if, simultaneously, the tracking error signal is above a second predetermined threshold value.

The invention is based on the perception that although the level of the HF signal falls when scanning dirty or damaged locations of the recording medium, the tracking error signal is nevertheless not appreciably disturbed by dirt or damage on the recording medium. Consequently, if it is only the HF signal which collapses, whereas the tracking error signal, the deviation of the actual value from the reference value, remains virtually at zero, then one can assume that the HF collapse was caused by dirt, damage or defects of the recording medium but not due to a change of track by the light beam. On the other hand, if the level of the HF signal falls below a first predetermined threshold value and the tracking error signal simultaneously rises above a second predetermined threshold value, then the light beam is no longer located on a track but rather, it is on the so-called grass, which is provided between the tracks.

There is shown in:

Figure 5 a first embodiment

Figure 6 a second embodiment

Figures 7 and 8 pulse diagrams for explaining the second embodiment.

The invention will now be described and explained with the aid of the first embodiment shown in Figure 5.

In Figure 5, the envelope EH of the HF signal HF is supplied to the first input of a comparator V1, on the second input of which, there is a reference voltage R1. The sinusoidal tracking error signal TE is supplied to the second input of a comparator V2, on the second input of which, there is a reference voltage R2. The outputs of the two comparators V1 and V2 are connected to the inputs of an AND gate U which emits a logical one at its output if the level of the HF signal HF lies below the reference voltage R1 and if, simultaneously, the tracking error signal TE is above the reference voltage R2.

The second embodiment shown in Figure 6 will now be described.

A pulse-shaped envelope-curve signal HP, which is obtained from the envelope of the HF signal, is supplied to the input of a monoflop M1 which can be triggered by a trailing edge. A pulse-shaped tracking error signal TZ, which is generated from the sinusoidal tracking error signal TE, is supplied to the first input of an OR gate O1 and to a monoflop M2 which can be triggered by a trailing edge. The inverted, pulse-shaped tracking error signal $\overline{TZ}$ is supplied to the first input of an OR gate O2 and to a monoflop M3 which can be triggered by a trailing edge. The outputs of the monoflops M2 and M3 are connected to the inputs of an OR gate O3 whose output is connected to the reset input of an RS flip-flop F6. The output of the monoflop M1 is connected to the first input of an AND gate U9 whose output is connected to the set input of the RS flip-flop F6. The one output of a directional logic circuit RL, which emits a logical one at either the one or the other of its outputs in dependence on the direction of movement of the light beam, is connected to the second input of the OR gate O1 whilst the other output of the directional logic RL is connected to the second input of the OR gate O2. The outputs of the OR gates O1 and O2 are connected to the inputs of an AND gate U10 whose output is connected to the second input of the AND gate U9. If the light beam is shining on the grass which is located between two tracks then the RS flip-flop F6 is set; on the other hand, it is reset if the light beam is aimed at a track.

The monoflop M1 emits a logical one at its output for each trailing edge of the pulse-shaped envelope-curve signal HP. Due

to the fact that the pulse-shaped envelope-curve signal HP is obtained from the envelope-curve of the HF signal, a trailing edge always occurs in the pulse-shaped envelope-curve signal HP when the level of the envelope-curve falls below a predetermined threshold value. If the light beam is moved in the one direction, the AND gate U10 emits a logical one for each positive pulse of the pulse-shaped envelope-curve signal TZ; the RS flip-flop F6 is only set if the monoflop M1 is set and, simultaneously, the pulse-shaped tracking error signal TZ is exhibiting a positive pulse. If the light beam is moved in the other direction, then the AND gate U10 emits a logical one for each positive pulse of the inverted pulse-shaped tracking error signal $\overline{TZ}$. The RS flip-flop F6 is set if the monoflop M1 is set and, simultaneously, the inverted pulse-shaped tracking error signal $\overline{TZ}$ is exhibiting a positive pulse.

The RS flip-flop F6 is reset by a trailing edge of the pulse-shaped tracking error signal TZ or by a leading edge of the inverted pulse-shaped tracking error signal $\overline{TZ}$.

In Figures 7 and 8, there are shown, the HF signal HF, the pulse-shaped envelope-curve signal HP formed therefrom, the sinusoidal tracking error signal TE, the pulse-shaped tracking error signal TZ, the inverted pulse-shaped tracking error signal $\overline{TZ}$, the output signals of the monoflops M1, M2 and M3, the signal at the output of the AND gates U9 and U10, the signal at the output of the OR gate O3 and also that at the output of the RS flip-flop F6.

In general, the invention is suitable for counting devices for counting markings or for control loops for positioning a unit, a scanner for example, in which the unit is positioned by means of scanning markings. The manner of scanning, mechanical or non-contact making, is irrelevant. The invention is suitable, in particular, for tracking control loops such as one may encounter in e.g. CD players, video disc players, DRAW-disc players or magneto-optic recording and/or reproducing devices.

Claims

1. Detector circuit for a tracking control loop which guides the light beam produced by an optical scanner along the data tracks of a recording medium, wherein the light beam scanning the items of data generates a HF signal (HF) and a tracking error signal (TE) and wherein it is checked as to whether the envelope (EH) of the HF signal (HF) falls below a first predetermined threshold value (R1), characterised in that, the detector circuit only emits a signal, which indicates that the light beam scanning the items of data is departing from a data track, if the envelope (EH) of the HF signal (HF) lies below the first predetermined threshold value (R1) and if, simultaneously, the tracking error signal (TE) is above a second predetermined threshold value (R2).

2. Detector circuit in accordance with Claim 1, characterised in that, the envelope (EH) of the HF signal (HF) is supplied to the first input of a first comparator (V1), on the second input of which, there is a first reference voltage (R1), that the tracking error signal (TE) is supplied to the first input of a second comparator (V2), on the second input of which, there is a second reference voltage (R2), and that the outputs of the comparators (V1, V2) are connected to the inputs of an AND gate (U) whose output signal indicates that the light beam is departing from a data track.

3. Detector circuit for a tracking control loop which guides the light beam produced by an optical scanner along the data tracks of a recording medium, wherein the light beam scanning the items of data generates a HF signal (HF) and a tracking error signal (TE) and wherein a pulse-shaped signal (HP) corresponding to the curve of the envelope is generated from the envelope (EH) of the HF signal (HF), characterised in that, a pulse-shaped tracking error signal (TZ) is produced from the tracking error signal (TE), that the pulse-shaped envelope-curve signal (HP) is supplied to a first monoflop (M1) which can be triggered by a trailing edge and the output of which is connected to the first input of a first AND gate (U9), that the pulse-shaped tracking error signal (TZ) is supplied to a second monoflop (M2) which can be triggered by a trailing edge and to the first input of a first OR gate (O1), that the inverted pulse-shaped tracking error signal ($\overline{TZ}$) is supplied to a third monoflop (M3) which can be triggered by a trailing edge and to the first input of a second OR gate (O2), that the outputs of the second and third monoflops (M2, M3) are connected to the inputs of a third OR gate (O3) whose output is connected to the reset input of an RS flip-flop (F6), that the output of the first AND gate (U9) is connected to the set input of the RS flip-flop (F6), that the outputs of the first and second OR gates (O1, O2) are connected to the inputs of a second AND gate (U10) whose output is

connected to the second input of the first AND gate (U9), that each output of a directional logic circuit (RL) is respectively connected to the second input of the first and second OR gates (O1, O2), that the directional logic circuit (RL) emits a logical one at either its one or other output in dependence on the direction of movement of the light beam and that the signal at the Q output of the RS flip-flop (F6) indicates whether the light beam is shining on a data track or on the space between two tracks.