

Device for correcting a video signal.

The invention relates to a device for correcting a video signal affected by line tilt and applied to an input of the device, including an adder circuit having two inputs for supplying a signal corrected at the output of the adder by adding said video signal to be corrected and applied with its total passband to the first input of the adder
5 and a correction signal applied to the second input of the adder.

Line tilt is a signal deformation caused by the overall transmission-transfer-receiving assembly, and more specifically by the poor tuning control of the receivers, a frequency shift introducing a deformation because of the attenuated side band.

10 On reception, the effect shows on the white or grey levels within a video line, in the form of inclined plateaus.

This effect is particularly annoying in the case of a scrambled transmission by pseudo-random permutation of line sections, as, when introduced in the transfer link between the scrambler and the descrambler, the line tilt becomes evident in
15 the fact that the picture elements which are placed side by side during the descrambling operation on either side of the cut-off point do not have the same luminance level. The descrambling operation converts this distortion in a "line noise" which is distributed in the image by the pseudo-random generator.

A device for correcting this fault is therefore used mainly in television
20 receivers, but may alternatively be useful in professional applications, for example for the correction before transmission in cable network head ends.

The document "A video scrambler/descrambler concept for the PAL format" by M. CHRISTIANSEN et al, Journal of the Institution of Electronic and Radio Engineers, Vol. 57, No. 1, pp. 27-35 January/February 1987, describes the
25 correction of the line tilt by adding to the video signal a sawtooth of the line frequency, whose amplitude and sign are adjusted to provide the best result.

It has nevertheless been found that by simply adding a sawtooth it is not possible to correct all the signal types, particularly because the slope of the level

depends on their amplitude. If instead of adding a signal, the signal is multiplied by a sawtooth, it will be found that the method only gives good results in particular cases.

The invention has for its object to provide a device which gives improved results and nevertheless remains very simple to realise.

5 The device according to the invention is characterized in that, for generating the correction signal, the device is provided with a frequency filter whose input receives the video signal to be corrected and whose output is connected to the second input of the adder via means for modifying the amplitude and/or the polarity of the correction signal.

10 The device thus realised adequately corrects all the signals used in practice, irrespective of their amplitude in particular.

The frequency filter used is advantageously a bandpass filter whose lower cut-off frequency is between 100 Hz and 20 Hz, and whose upper cut-off frequency is between 20 kHz and 1 MHz.

15 It is also desirable to be able to control the amplitude of the correction signal to optimise the correction. To this end, the means for modifying the amplitude and/or the polarity of the correction signal are controllable.

When a filter, whose output signal is added at least partly to the main signal, is incorporated in a path, there is a risk that transitory signals are deformed as a
20 result of the group delay introduced by this filter. Advantageously, to remedy this drawback, a delay element is inserted in the signal path leading to the first input of the adder.

The following description which is given by way of non-limitative example with reference to the accompanying drawings will make it better understood
25 how the invention can be put into effect.

Fig. 1 shows several video signals to illustrate the disturbing effect of the line tilt during a scrambling/descrambling operation.

Fig. 2 shows several video signals to illustrate different correction methods in accordance with the prior art.

30 Fig. 3 is a very schematic representation of a device according to the invention.

Fig. 4 is a detailed circuit diagram of an embodiment of the invention.

Fig. 5 is a block circuit diagram of a descrambler provided with a device

according to the invention.

Fig. 6 is a flow chart of the operations for determining the control value to be applied to the device according to the invention.

Fig. 1-a shows a video signal which represents a constant grey level throughout a line. This signal is scrambled by permuting line portions, that is to say, the portion A represents the beginning of the line and the portion B represents the remaining portion of the line. On reception, these portions A and B must be inverted by separating them at the instant indicated by the line 41.

Fig. 1-b shows the same signal after transmission. It is affected by the line tilt fault which becomes manifest as an abnormal slope relative to the horizontal indicated by the line 42. After permutation of the portions A and B, the signal shown at c has in the region of the line 41 a parasitic luminance difference which is visible in the reproduced image.

Fig. 2 shows different cases of signals affected by faults or not affected by faults. In each of these cases several different grey levels superposed one on the other in the same line are shown. The signal shown at c is the ideal signal, either available on transmission or obtained on reception after a perfect correction. The signals "a" and "b" show two typical faults. At "a" the slope of the levels is proportional to the amplitude, while at "b" the slope is constant irrespective of the amplitude. If an appropriate sawtooth is added to the signal "b" the signal "c" is obtained. If the signal "a" is multiplied by an appropriate sawtooth, the signal "c" is also obtained, and in these particular cases the correction obtained is perfect. But if a constant sawtooth which corresponds to the slope of the signal for an average amplitude is added to the "a" signal, the signal "e" is obtained; if the signal "b" is multiplied by a sawtooth; the signal "d" is obtained. These two signals "e" and "d" are not correct. In order to obtain a proper correction, it is therefore necessary to choose at each instant between multiplication or addition and furthermore to adapt the amplitude of the correction sawtooth. It also occurs that the slope is not constant along the overall line, in which case there is no sawtooth which yields a satisfactory result.

Fig. 3 shows a basic circuit diagram of a device according to the invention which solves the above problems. A video signal affected by line tilt is applied to an input 36. This signal is applied with its complete passband to the first input 47 of an adder 37. The second input 48 of the adder 37 is connected to the output

of a filter 38 via controllable means 39, 40, 45, 46, which will be described in detail hereinafter. The input signal at 36 is applied to an input 49 of the filter 38 which is a bandpass filter. The corrected signal is supplied from the output 35 of the adder 37.

To compensate for the group delay time of the filter 38, a delay line 30 is
5 incorporated in the signal path leading to the first input 47 of the adder 37. This delay element must not affect the frequency content of the video signal to a significant extent.

To control the amplitude and the polarity of the correction signal coming from the filter 38, controllable means 39, 40, 45, 46 are provided between the output of the filter 38 and the second input 48 of the adder 37. These means are constituted by
10 separating the output link of the filter 38 into two channels 45 and 46, the channel 46 including an element 39 which inverts the polarity of the signal without modifying its amplitude or its shape. The channel 45 ends at one of the resistor terminals of the resistance of a potentiometer 40, and the output of the element 39 is connected to the other terminal. This potentiometer is a controllable mixer whose two resistance
15 terminals play the role of two inputs for the signals to be mixed. The wiper of the potentiometer, which represents the output of the mixed signal is connected to said second input 48 of the filter 37.

When the wiper is in the extreme left-hand position (in Fig. 3) of the potentiometer 40, the signal coming from the filter is applied directly to the input 48.
20 When the wiper is in the extreme right-hand position, the inverted signal is applied to the input 48, that is to say, the output signal of the filter 38 is subtracted in the adder 37 from the signal 36 to be corrected. In the exact central position of the wiper the signals which are the inverse of each other in the paths 45 and 46, 39 are subtracted from each other and are cancelled and no correction is effected. All types of
25 intermediate controls are possible. A method of determining the optimum control will be described hereinafter, and also a circuit which performs the function of the potentiometer 40 but may be controlled by electric signals.

To avoid a difference between the inverted signal and the direct signal due to the passage through the inverter 39 it would alternatively be possible to incorporate
30 an operational amplifier (not shown) in each of the channels 45 and 46, conveying the signal to the + input of the amplifier through one of the channels and to the - input via the other channel. It is alternatively possible to use a four-quadrant multiplier which is commercially available as an integrated circuit, one of whose inputs is connected to the

output of the filter, the other input is connected to a control signal generator, and whose output is connected to said second input of the adder. This solution is utilised in the embodiment which is shown in greater detail in Fig. 4 and which will now be described.

- 5 The signal to be corrected is applied to the input 36. From this input a horizontal connection in the Figure leads to the filter 17-21 and a connection directed towards the bottom in the Figure leads to the mixer 28, 29 without modification of the passband.

 From the input 36 the resistance bridge 43, 18 which has its end
10 connected to ground forms a fixed attenuator and, because of the capacitor 17 which is arranged in series with the resistor 43 at the same time forms a first-order high-pass filter, whose cut-off frequency is between 100 Hz and 20 kHz. In combination with the values indicated hereinafter, the cut-off frequency is here approximately 13 kHz. Arranged in cascade with this filter 43, 17, 18 is a second filter 19, 20, 21 which is
15 constituted by a series-arranged self-induction 19 and a resistor 20 which is arranged in parallel with a capacitor 21 one end of which is connected to ground. This filter is a second-order low-pass filter whose cut-off frequency is between 20 kHz and 1 MHz. In combination with the values indicated hereinafter, the cut-off frequency is here approximately 700 kHz. The output of this filter is applied to the input 15 of an
20 integrated circuit which is commercially available under the type designation TLC7524. This circuit is a digital-to-analog converter which can perform the four-quadrant multiplier function: the input 15 is arranged to receive an analog signal, and the inputs 4-11 receive an 8-bit digital value conveyed via a multi-wire conductor 23; the circuit effects the multiplication of the analog signal by the digital value which may be positive
25 or negative, and supplies the result as an analog signal from the output 1. In accordance with the indication given by the constructor, this output is led to the - input of an operational amplifier 22 whose output is fed back to the terminal 16 of the integrated circuit. The +5 V supply voltage is applied to the input 14 and the inputs 3, 12, 13 are connected to ground.

- 30 The signal available at the terminal 16 of the integrated circuit is mixed with the input signal at the terminal 15 via two resistors which are arranged in series between these two terminals. The junction point of these two resistors is connected to the - input of an operational amplifier 44 which is arranged as a conventional inverter

amplifier with feedback to fix the gain by a resistor 27, the + input being connected to ground via a resistor 26. The amplitude and polarity-adjusted correction signal then finally becomes available at the output of the amplifier 44 on the terminal 51.

The other input branch (the vertical branch) includes the delay line 30
5 arranged in series with a matching resistor 31. The video signal to be corrected is available at 50. A resistor-capacitor network 32-34 acts as an impedance matching and passband correction device for the delay line.

The adder is simply formed by two resistors 28 and 29 arranged in series
10 between the terminal 50 and the terminal 51, the corrected signal ultimately being available at 35, at the centre point of the two resistors 28; 29.

This circuit is incorporated in the housing of a descrambler associated with a television receiver, between the demodulated video source of the set and the descrambler circuits.

An embodiment using the following elements (Fig. 4) has yielded good

15 results:

<u>Resistors:</u>	<u>Capacitors:</u>
18: 100 Ω	17 = 10 nF
20: 100 Ω	21 = 2,2 nF
24: 15 k Ω	34 = 820 pF
20 25: 30 k Ω	self inductance:
26: 7,5 k Ω	19 = 22 μ H
27: adjustable from 30 to 80 k Ω	
28: 100 Ω	operational amplifiers
29: 100 Ω	22, 44 = 2x1/2 LF 353
25 31: adjustable, 220 Ω max.	
32: 820 Ω	delay line:
33: 82 Ω	delay $\approx$ 0.9 μ s
43: 1,1 k Ω	$\approx$ 150 Ω characteristic impedance

A method of choosing the control value of the correction will now be
30 described. As the amplitude control input of the multiplier is a digital input in this case, the determination of the correction value can be effected by digital means.

In accordance with a CCIR recommendation, there is a horizontal plateau in the 17th line, the "luminance plateau". In other standards equivalent plateaus are

always present: the invention can also be used with great advantage for decoding transmissions in accordance with a MAC standard, for which the "line tilt" problem is particularly serious when scrambling/descrambling is used.

The amplitude of the signal at the two extreme ends of a luminance plateau is, for example, sampled and the measured values are processed in a digital processor. This digital processor may advantageously store several values and by taking the average it can reduce the occurrence of samples which are incorrect due to noise. The system operates by feedback, the processor calculating the correction which permits converging in an optimum manner towards a deformation less than a predetermined value.

In Fig. 5 which shows a portion of the video channel of a receiver provided with a descrambler, the scrambled signal is applied to the terminal 36 and the descrambled signal is supplied as an output signal from the terminal 67. This signal passes successively through an element 60 which includes the circuit shown in Fig. 4 (with the same input/output reference numerals 36, 23, 35), an analog-to-digital converter 61, a processing circuit 62, and finally a digital-to-analog converter 63. The signal from the terminal 36 is also conveyed to a synchronization recovery circuit 66 which applies the instants at which the line and field retrace start to a decoding circuit 64 and to a microprocessor 65. The element 62 includes two memories which are used alternately for one line and the other and each of which is capable of storing all the digitized video data of one line so as to proceed to inversion of line segments by modifying the addressing sequence of the memories. The element 64 is a real-time interface circuit which manages the memory addresses much faster than would be possible for the microprocessor 65 which, in its turn, manages the control words at a slower rate. The overall assembly of these elements 62, 64, 65, 66 therefore serves in known manner for the actual descrambling, which does not form part of the invention.

These same elements are also used to determine the optimum control of the line tilt correction. To this effect the decoding circuit 64 is provided with a time counter which, on the basis of the line retrace instants supplied by the separator 66, supplies a signal at the start and at the end of the luminance plateaus of the test line. In the processing element 62 this signal triggers the taking of several consecutive samples from the signal to be corrected at the beginning of the luminance plateau, and again several consecutive samples at the end of this plateau. The element 62 is provided with

additional memories for storing these samples which are thereafter applied via the connection 68 to the microprocessor 65 which calculates the average of the samples of the start of the plateau and the average of the samples of the end of the plateau, and thereafter determines the slope of the luminance plateau from the difference between the samples of the beginning and the end of the plateau. The processor then calculates a correction value which is applied via the connection 23 to the correction element 60 in the form of a word, for example an 8-bit word.

The method of calculation by the microprocessor 65 is shown in Fig. 6, in the form of a flow chart. The rectangles symbolize the following respective operations:

- 10 52 : calculation of the average of the samples over several fields.
- 53 : testing the presence of the luminance plateau. (Y = yes, N = no)
- 54 : calculation of the slope of the luminance plateau.
- 55 : testing the value of the slope: Y = slope lower than the fixed threshold N = slope higher than the fixed threshold.
- 15 56 : unchanged correction.
- 57 : calculation of the new correction.
- 58 : reading the result of the calculation 57.
- 59 : zero correction.

The calculation (operation 52) of the average of the two groups of samples taken more particularly renders it possible to get rid of the influence of noise and rapid fluctuations on the tested reference plateau.

From the value of these groups of samples it is possible to deduce (operation 53) the presence or the absence of the test plateau. If absent, the correction is merely and simply cancelled (an elementary precaution consists in taking this measure only after the absence of the test plateau has been found several times consecutively).

Reading (operation 58) consists in determining an average of the correction calculated at a predetermined instant and of a weighted sum of the preceding corrections, in such a way that an instability in the correction is avoided.

Testing in the operation 55 whether the fault is below a predetermined value and, if so, to apply the preceding correction value again renders it possible to avoid oscillations of a small amplitude around the ideal value.

CLAIMS:

1. A device for correcting a video signal affected by line tilt, and applied to an input (36) of the device, including an adder circuit (37) having two inputs for supplying a signal corrected at the output (35) of the adder by adding said video signal to be corrected and applied with its total passband to the first input (47) of the adder
5 and a correction signal applied to the second input (48) of the adder, characterized in that, for generating the correction signal, the device is provided with a frequency filter (38) whose input (49) receives the video signal to be corrected and whose output is connected to the second input (48) of the adder via means (40, 27) for modifying the amplitude and/or the polarity of the correction signal.
- 10 2. A device as claimed in Claim 1, characterized in that the filter (38) is a bandpass filter.
3. A device as claimed in Claim 2, characterized in that the filter (38) is formed by the cascade arrangement of a low-pass filter (19-21) and a high-pass filter (17, 18).
- 15 4. A device as claimed in Claim 2, characterized in that the lower cut-off frequency of the filter is between 100 Hz and 20 kHz.
5. A device as claimed in Claim 2, characterized in that the upper cut-off frequency of the filter is between 20 kHz and 1 MHz.
6. A device as claimed in any one of Claims 1 to 5, characterized in that it
20 includes a delay element (30) provided in the signal path leading from the input of the device (36) to the first input (47) of the adder.
7. A device as claimed in any one of Claims 1 to 6, characterized in that the means (40, 27) for modifying the amplitude and/or the polarity of the correction signal are controllable.
- 25 8. A device as claimed in Claim 7, characterized in that said controllable means (40, 27) are constituted by the separation of the output coupling of the filter into two channels (45, 46) one of which comprises an inverting element (39), these two channels each leading to one of two inputs of a controllable mixer (40) whose mixed



signal output is coupled to said second input (48) of the adder.

9. A device as claimed in Claim 7, characterized in that said controllable means (40, 27) are constituted by a four-quadrant multiplier which has one of its inputs (15) coupled to the output of the filter, the other input (4-11) to a control signal generator and its output (16) to said second input (51) of the adder.

10. A device as claimed in any one of Claims 7 to 9, characterized in that it includes a digital processor (65) which is used for determining the control value of the controllable means (40, 27), this digital processor being loaded with software which, on the basis of a luminance plateau of a test line controls the following operations: taking several consecutive samples of the signal to be corrected at the beginning of the luminance plateau, and again several consecutive samples at the end of this plateau, calculating (52) the average of the samples over a plurality of fields, a luminance plateau presence test (53), calculating and testing (54, 55) the value of the slope and thereafter calculating (57) the new correction which permits converging in an optimum manner towards a deformation less than a predetermined value.

