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DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Signal Translating System

We, RADIO CORPORATION OF AMERICA, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to signal translating systems and particularly to a system for translating a video signal to substantially reduce the amplitude of its low frequency signal content.

In video magnetic records, it has been the practice to frequency modulate the video signal to be recorded. Attempts have also been made to record the video signal directly, thus eliminating the need for frequency modulation and demodulation. However, a recording system designed to have good high frequency response, necessary for high quality recording and reproduction, has limited low frequency response.

This deficiency can be partly corrected by frequency response equalising circuits in the playback system. Such technique is limited by the relatively poor signal-to-noise ratio of the low frequency components obtained from the playback circuit. This result can be expected because a typical magnetic recording system reproduces low frequency signals with a gain characteristic which varies inversely with the square of frequency. On the other hand, sources of noise in the system, such as play-back amplifier noise, have spectrums which are more nearly uniform with frequency.

Signal components having frequencies much lower than the line scanning rate need not be reproduced if a keyed clamping technique is used to set either the sync tips or the blanking portions of the video signal to a prescribed level. By this means, very low frequency components, including DC, are restored, When rapid clamping action is attempted to restore components having frequencies only slightly below the line scanning rate, high frequency noise occurring during the clamping operation may introduce errors which can be more objectionable in the appearance of the television picture than the high frequency noise itself.

In addition, to this practical limitation, clamping can not eliminate the need for frequency components slightly lower than the line scanning rate because they contribute to the faithful reproduction of waveforms during intervals between the clamping periods. In a typical television system with a 15.75 KC line rate, signal components as low as 1.5 KC must be reproduced in correct phase and amplitude to avoid detectable distortion between clamping periods.

Attempts to pre-emphasize low frequency components before recording have been unsuccessful because their magnitude in typical signals overload the recording head or otherwise exceed the useful dynamic range of the head and tape characteristic.

It is therefore an object of the present invention to provide a new and improved system for processing a video signal to reduce the amplitude of its low frequency signal content.

With the above object in mind, the present invention relates to a signal translating system including means for providing a video signal and utilization means for the video signal. The signal translating system includes polarity inverting means coupled between the video signal and the utilization means for inverting the polarity of portions of the video signal at a rate substantially less than the highest video frequency. This reduces substantially the amplitude of the low frequency components of the video signal.

[*Price 4s. 6d.*]

In the accompanying drawings:

FIGURE 1a is a block diagram of the video recording system embodying the principles of the present invention;

FIGURE 1b is a block diagram of a video reproducing system embodying the principles of the present invention;

FIGURE 1c is a block diagram of another reproducing system embodying the principles of the present invention;

FIGURE 2 illustrates schematically a circuit which may be employed in the system of FIGURE 1a;

FIGURE 3 is a graphical representation of a series of waveforms useful in describing the operation of the recording portion of the system shown in FIGURE 1a;

FIGURE 4 illustrates schematically a modification of the circuit of FIGURE 2 and which may be employed in the system of FIGURE 1a; and

FIGURE 5 is a graphical representation of a series of waveforms useful in describing the operation of the reproducing portion of the system shown in FIGURE 1b.

The principles of the present invention will be explained with reference to those parts of a magnetic recording system which involve the processing of a video signal before its application to the recording head and after its retrieval from the playback head. Any description of the structural arrangement of the heads, capstan and drive mechanism associated with magnetic records, the details of which are known to those skilled in the art but which have no bearing on the present invention, have been omitted.

Referring now to FIGURE 1a wherein a block diagram illustrating one embodiment of the recording portion of the invention is shown, a video signal to be recorded is simultaneously applied to the respective input terminals of a horizontal sync separator 10 and a pair of sampling devices or switches 12 and 14. Such video signal may be a television signal representative of successive scanning intervals, containing picture information components and recurrent synchronizing information components, with the picture information components also including blanking components.

The output wave from the horizontal sync separator 10 comprises a series of pulses corresponding to the horizontal synchronizing pulses contained in the applied video signal. Switches 12 and 14 are designed to pass or gate alternately selected portions of the applied video signal corresponding to successive scanning intervals to the respective switch output terminals 16 and 16' for further processing as will be hereinafter described.

The gating of switches 12 and 14 is controlled by a series of gating pulses developed at a bistable multivibrator 24 and alternating between its output terminals 20 and 22. The multivibrator 24 is triggered by the output pulses from the horizontal sync separator 10. It is designed to produce gating pulses beginning and ending at times coincident with the trailing edges of consecutive horizontal sync pulse portions of the video signal and equal to one television line in duration.

Application of the gating pulses to the switches 12 and 14 causes portions of the applied video signal corresponding to alternate scanning intervals to appear sequentially at the respective switch output terminals 16 and 16'. The signal at each output terminal substantially comprises one half the applied video signal with the sum of the two output signals being equal to the applied input signal plus the gate signal component.

The output signal from switch 12 is passed through an inverter 26 and then applied to an adding network 28. The inverter reverses the polarity of the signal applied. The output signal from switch 14 is also applied to the adding network 28 and is combined with the inverted polarity signal from switch 12. The combined signal with the polarity of the signal portions corresponding to alternate scanning intervals reversed then appears at the output terminal 30 of the adding network 28.

Before describing in greater particularity the apparatus incorporating the principles of the present invention, it may be noted that FIGURE 2 illustrates circuitry suitable for performing the functions of the gated switches 12 and 14 of FIGURE 1a. By way of example, gated switches 12 and 14 may each include a multi-electron tube 40 and 41 such as a 6AS6. The tube 40 has an anode 42, a cathode 44, and first, second and third electrodes 46, 48 and 50. The tube 41 has corresponding electrodes designated by the same reference numeral with a prime.

The video signal to be sampled by the switches 12 and 14 is shown in FIGURE 3a and is applied to a terminal 52 with sync excursions in the negative direction, for application to the third grid electrodes 50 and 50'. The gating pulses from the multivibrator 24 are shown in FIGURES 3b and 3c and are applied to terminals 54 and 54', respectively, for application to the grid electrodes 46 and 46'. That is, the output from terminal 20 of multivibrator 24 is shown in FIGURE 3b and is applied to terminal 54. The output from terminal 22 is shown in FIGURE 3c and is applied to terminal 54'.

From an inspection of the circuit it will be seen that the plate currents through the tubes 40 and 41 are respectively dependent upon the potentials applied to both the grid electrodes 46 and 46' and the grid electrodes 50 and 50'. The gating signal will appear in the plate current of each tube, even when there is no video input signal.

Sync tips of the input video signal are set

by a diode 56 and a potential source 58 to −4.5 volts. Under these conditions, the control actions of grid electrodes 50 and 50′ are essentially linear. FIGURE 3d represents the alternately gated output signal appearing at terminal 16′ of switch 14 due to the application of the gating signal shown in FIGURE 3b on video signal shown in FIGURE 3a. The output signal from switch 12 is obtained in a similar way and is shown in FIGURE 3e after inversion in the inverter 26. FIGURE 3f represents the combined signal appearing at the output terminal 30 of the adding network 28.

It will be noted that FIGURE 3 is drawn with the gating signal waveforms coincident with the trailing edge of the sync pulse portions of the video signal. As will be hereinafter disclosed, the timing of the gating pulse is arbitrary and has significance only in the ease with which the horizontal sync pulses can be separated from the reconstructed playback signal.

Because the plate currents of the tubes 40 and 41 do not go to zero at sync tips with the bias values shown, the waveforms in FIGURES 3 (d), (e) and (f) have large gating signal components. As will be shown, this may be desirable depending upon the relative extent of non-linearity of the recording medium.

In particular, the magnitude of the added gating pulse in FIGURE 3f can be set by adjusting the potential of the bias battery 58 in the third grid electrode circuit of tubes 40 and 41. If the bias is increased to the point where the plate current of each tube is cut-off at sync tips, the waveform shown in FIGURE 3g will be produced at the output terminal 30 of the adding network 28.

It will be apparent that the waveform of FIGURE 3g can also be produced by adding in appropriate magnitude the gating signal shown in FIGURE 3b to the waveform shown in FIGURE 3f. Thus, the waveform of FIGURE 3g is a special case of the waveform shown in FIGURE 3f.

Waveform 3h illustrates another special case of the waveform shown in 3f and is produced by adding a still greater magnitude of the gating signal 3b than was used to produce 3f. It will be apparent that many modifications of the waveforms shown in FIGURES 3f, 3g and 3h can be produced, depending on the relative magnitudes of the applied video and gating signals as well as the bias values utilized with tubes 40 and 41.

The waveform shown in FIGURE 3g may also be produced by a modified balanced version of the circuit of FIGURE 2 as illustrated in FIGURE 4. Here the video signal applied to the third electrode grids 50 and 50′ varies the relative portions of cathode currents which reach the plates 42 and 42′ and the screen or second grid electrodes 48 and 48′ of the tubes 40 and 41. Thus, the current in the screen grids 48 and 48′ attributable to the video signal has a polarity opposite to that in the respective plates 42 and 42′.

As shown in FIGURE 4, in addition to being returned to a B+ screen supply 60, through resistors 68 and 68′, respectively, the screen grids 48 and 48′, respectively, are AC coupled to the control grids 62 and 62′ of a pair of triode electron tubes 64 and 64′, each operating as an amplifier. The plates 66 and 66′ of the triodes 64 and 64′ are respectively direct coupled to the plates 42 and 42′ of the tubes 40 and 41. The screen current develops a voltage drop across the screen grid resistors 68 and 68′ which is then amplified, inverted, and added as an aiding video signal current to the plate circuits of the tubes 40 and 41.

On the other hand, the currents in the screen grids 48 and 48′ and plates 42 and 42′ of each of the tubes 40 and 41 attributable to the respective gating signals are of the same polarity. The portion of this current in the plate circuit of the tubes 40 and 41 is then cancelled out by the inverting action of the triode amplifiers.

The gain of each triode amplifier 64 and 64′ is controlled by means of respective variable feedback resistors 70 and 70′ in the amplifier cathode circuits. By this means the gating pulse signal in the plates 42 and 42′ can be cancelled for a given potential in the third electrode grid circuits of tubes 40 and 41, such as that corresponding to the sync tip level, thus producing an effect similar to having the sync tips at cut-off.

An analysis of the waveform signal shown in FIGURES 3 (f), (g) and (h) will reveal that the DC component of the original video signal is no longer present in the illustrated waveforms, and furthermore that the amplitude of low frequency components of the waveforms, will be small, except for the special case of repetitive detail occurring during alternatively successive scanning intervals.

In FIGURE 3, gating of the video signal has been shown to occur coincident in time with the trailing edge of the horizontal sync pulses. As mentioned earlier, the timing of the gating pulses will be determined by considerations of obtaining horizontal sync signals from the playback signal with ease and accuracy. It will be appreciated that gating could be timed to switch during the sync pulse, or coincident with the leading edge of the sync pulse, or on the front porch of the horizontal blanking interval before the leading edge of the sync pulse or on the back porch of the horizontal blanking interval after the trailing edge of sync. It will be noted that switching and inversion could be made to occur at a rate other than that of one half the scanning frequency, as for ex-

ample, a rate equal to or greater than the scanning frequency and less than the highest video frequency to be recorded and reproduced, without departing from the scope of the invention so as to still greatly reduce or attenuate the low frequency components of the video signal.

Referring again to FIGURE 1a, the combined video signal output from the adding network 28 is passed through a low frequency pre-emphasis network 32 and then applied to a recording head driver 34. The signal then goes to a suitable transducer 36 for recording on a magnetic tape.

It will be noted that because of the polarity reversal of portions of the video signal corresponding to alternate scanning intervals, and the resulting reduction or attenuation of the low frequency components of the video signal, pre-emphasis of the low frequency components of the signal can be achieved without overloading the recording head. Furthermore, the reduction in recorded low frequency components minimizes problems of cross-coupling between adjacent tape tracks.

In addition, the combined video signal represented in FIGURES 3 (f) and 3 (g) can be recorded on magnetic tape without AC or DC biasing of either the recording head or tape. As heretofore described, the DC level of the horizontal sync pulse components of the applied video signal can be adjusted so that the portions of the combined video signal corresponding to the horizontal sync pulses fill the non-linear region of the magnetic tape transfer characteristic.

If desired, the sync pulses can be predistorted, for example, by a process known in the art as sync stretching, to compensate for the distortion imparted to the sync pulses due to the non-linear portion of the transfer characteristic. Since the combined video signal will typically contain a very small or no DC component at all, AC coupling can be used. If desired sync tips can be clamped to a constant level, to correct for the small DC component that may be present in the combined video signal. In particular, the sync tips of the waveform shown in FIGURE 3g can be clamped to a level of zero recording coil current.

In the case of waveform 3f, the DC component can be restored by clamping at either or both of the sync tip levels. The picture information portion of the combined video signal will then be in the linear region of the transfer characteristic and will therefore be recorded with a minimum of distortion.

Referring now to FIGURE 1(b), there is shown a reproducing system embodying the principles of the invention and suitable for reproducing the recorded information illustrated by the waveforms shown in FIGURES 3f or 3g. The recorded information is converted into an electrical signal with alternate polarity portions corresponding to successive scanning intervals, by means of a transducer 80 which is coupled to a video playback amplifier 82. The output of the amplifier 82 is applied to the input of a phase splitter 84. The phase splitter 84 provides a pair of output signals at terminals 86 and 88, respectively, and corresponding to the applied input signal, with one of the output signals being equal in magnitude but opposite in polarity to the other output signal.

The output signal from terminal 86 of the phase splitter 84 is applied to the input terminal 90 of an amplifier 92. The amplifier 92 is biased to cut off at a level corresponding to the tip of the horizontal sync pulse portion associated with the desired half cycle portions of the input signal. The amplifier 92 effectively acts as a rectifying device or half wave clipper and thus provides a signal at its output terminal 94 which is derived from the positive going portions of the applied signal.

Correspondingly, the output signal from the terminal 88 of the phase splitter 84 is applied to the input terminal 96 of an amplifier 98 which is also biased to cut-off at horizontal sync tip. Since the signal at terminal 88 of the phase splitter 84 is opposite in polarity to the signal appearing at terminal 86 of the phase splitter 84, the signal at the output terminal 100 of the amplifier 98 will appear alternately with respect to the output signal from the amplifier 92, each signal occurring without interruption for a period equal to one television scanning line.

The signal obtained at the output terminal 94 of the amplifier 92 is then applied to an adding network 102. The output signal from the amplifier 98 is also applied to the adding network 102 for combination with the signal received from the amplifier 92. The reproduced video signal appears at the output terminal 104 of the adding network 102. The reproduced signal may then be inverted so as to have negative going horizontal sync tips in comformance with the original recorded signal.

The reconstructed video signal may then be applied to a television transmitter or local television monitor for viewing.

The operation of the reproducing system just described can best be understood by referring to FIGURE 5 wherein the signals appearing at the output of successive stages of the reproducing system are illustrated. FIGURE 5a represents the playback signal obtained at one of the output terminals (for example 86) of the phase splitter 84 and also corresponds to the signal to be recorded as shown in FIGURE 3f.

FIGURE 5b represents the signal appearing at the other output terminal 88 of the phase splitter 84. In conformance with the operation of a phase splitter, the signals at

terminals 86 and 88 are shown as being equal and of opposite polarity.

FIGURES 5c and 5d represent the signals appearing at the respective output terminals 94 and 100 of amplifiers 92 and 98. Since the amplifiers are both biased to cut-off of horizontal sync tip, only portions of the applied signals above the sync tip will be amplified and inverted. Thus, the output of amplifier 92 (FIGURE 5c) represents portions of the reproduced video signal corresponding to alternate scanning intervals. The output of amplifier 98 (FIGURE 5d) represents portions of the reproduced video signal which are interspaced between the alternate scanning interval output of amplifier 92. The outputs from the two amplifiers 92 and 98 can then be added and inverted to produce the original video signal (FIGURE 5e).

Referring now to FIGURE 1c, there is shown a reproducing system embodying the principles of the invention and suitable for reproducing the recorded information illustrated by the waveform shown in FIGURE 3h. The recorded information is converted into an electrical signal with alternate polarity portions corresponding to successive scanning intervals by means of a transducer 80 which is coupled to a video playback amplifier 110. The output of the amplifier 110 is applied to the input terminals of a phase splitter 112. The phase splitter 112 provides a pair of output signals at terminals 114 and 116, respectively, which correspond to the applied input signals, with one of the output signals being equal in magnitude but opposite in polarity to the other output signal.

The output signal from terminal 114 of the phase splitter 112 is simultaneously applied to a horizontal sync separator 118 and the input terminal of a gated switch 120. Correspondingly, the output signal from terminal 116 of phase splitter 112 is simultaneously applied to a horizontal sync separator 122 and the input terminal of a gated switch 124.

The output from the horizontal sync separator 118 comprises a series of pulses corresponding to alternately selected ones of the horizontal synchronizing components contained in the electrical signal. The output from the sync separator 122 comprises a series of pulses corresponding to the non-selected synchronizing components of the electrical signal, with the combined output from sync separators 120 and 124 being representative of the total synchronizing components contained in the electrical signal.

Gate switches 120 and 124 are designed to pass or gate alternately selected portions of the applied electrical signal corresponding to successive scanning intervals to the respective switch output terminals 126 and 128 for further processing, as will hereinafter be described.

The gating of switches 120 and 124 are respectively controlled by a series of gate pulses developed at and alternating between the output terminals 130 and 132 of a bistable multivibrator 134. The multivibrator 134 is triggered by the output pulses received from the sync separators 118 and 122 to produce gating pulses which alternate between its output terminals 130 and 132. The output from terminal 130 of the multivibrator is coupled to a gating input terminal 136 of switch 120, and the output from multivibrator terminal 132 is coupled to the gate input terminal 138 of switch 124.

The gate pulses applied to the switches 120 and 124 cause portions of the reproduced signal corresponding to alternate scanning intervals to appear sequentially at the respective switch output terminals 126 and 128. The signal at each output terminal substantially comprises one half the applied electrical signal. The signals obtained at the output terminals 126 and 128 of respective switches 120 and 124 are then applied to an adding network 140 wherein the two signals are combined to produce an output signal representative of the original video signal.

By the system described, it will be noted that portions of the video signal corresponding to each scanning interval of a television raster is recorded in alternate polarity. Any dissimilarity encountered in the reproduced signal during alternate scanning intervals tends to be averaged visually after four fields in a television system with two to one interlacing. Experience has shown that this is a desirable characteristic when dissimilarity is moderate.

Severe dissimilarity may cause line crawling. This is a flicker phenomenon and can be corrected by resetting the multivibrator pulse output at a frame rate. Dissimilarity then produces a pattern which is relatively coarse, but experience has shown this to be preferable to a crawling pattern when dissymmetry of unbalance is substantial. A method for resetting the multivibrator at the beginning of each field or frame is disclosed in U.S. Patent No. 2,896,016, entitled "Color Image Reproducing Aparatus".

Thus, in accordance with the principles of the present invention, a system for magnetically recording a video signal has been shown. It has been shown that by inverting the polarity of portions of the signal, the low frequency components contained in the signal are substantially reduced in amplitude so as to thereafter permit pre-emphasizing of the low frequency components prior to recording without overloading the recording head. In one embodiment the polarity of the signal was illustrated as being inverted at a rate equal to one half the rate of the recurrent synchronizing components contained in the signal.

WHAT WE CLAIM IS:—

1. A signal translating system including means for providing a video signal and utilization means for said video signal, said system being characterized by polarity inverting means coupled between said video signal and said utilization means for inverting the polarity of portions of said video signal at a rate substantially less than the highest video frequency, to reduce substantially the amplitude of the low frequency components of said video signal, said system including pre-emphasizing means for pre-emphasizing said low frequency components, said pre-emphasizing means being coupled between said polarity inverting means and said utilization means.

2. A signal translating system as defined in Claim 1 wherein said utilization means includes a magnetic recording device for recording, on a magnetic recording medium, the modified video signal with portions inverted in polarity.

3. A signal translating system as defined in Claim 1 or 2 wherein the portions of said modified video signal inverted in polarity are of opposite polarity with respect to a datum potential than the non-inverted portions of said video signal.

4. A signal translating system as defined in Claims 2 or 3, wherein said video signal includes picture information components and said recording medium has a transfer characteristic including a substantially linear region, said picture information components of said video signal being recorded within the linear region of the transfer characteristic of said recording medium.

5. A signal translating system in accordance with any one of the preceding claims, wherein said video signal includes recurrent horizontal synchronizing signal components.

6. A signal translating system as defined in Claim 5 wherein the polarity of said video signal is inverted at a rate equal to one half the rate of said recurrent synchronizing signal components.

7. A signal translating system in accordance with any one of the preceding claims including input circuit means for receiving said modified video signal, second utilization means, and means coupled between said input circuit means and said second utilization means for synchronously inverting the polarity of one of said portions of said modified video signal at said rate to derive a signal corresponding to said video signal before modification.

8. A signal translating system as defined in Claim 7 wherein said input circuit means includes a magnetic transducing device for reproducing said modified video signal from a magnetic recording medium.

9. A signal translating system in accordance with Claim 1, wherein said means for providing said video signal provides a first electrical signal representing successive scanning intervals, wherein said first signal contains recurrent blanking components each occupying a blanking interval, means for generating gating pulses of which the edges occur during successive blanking intervals of the said first signal, means adapted to receive said first electrical signal and responsive to said gating pulses for producing a second electrical signal similar to said first electrical signal but having its polarity inverted during alternate scanning intervals, and means coupled to said last-mentioned means for recording said second electrical signal on a recording medium.

10. A process of magnetic recording and reproduction of a video signal over a wide frequency range extending upward from DC to a predetermined upper frequency, comprising the steps of

a) receiving the signals to be recorded and regularly inverting the polarity of portions of such signals at a rate substantially less than said upper frequency,
b) recording the signals resultant from step (a) on a magnetic recording medium,
c) playing back the recorded signals,
d) restoring the polarity of inverted portions of the signals played back, and
e) reproducing the restored signals.

11. A signal translating system substantially as described with respect to the accompanying drawings.

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