

VIDEO PLAYBACK SYSTEM

The present invention relates generally to apparatus and a method for processing video signals comprising chrominance and luminance signals and, more particularly, to video signals as generally processed in a video tape recorder wherein a separate channel is used for recording a chrominance signal on a magnetic tape.

As is known, the spectrum of a luminance (and sync) television signal includes a dc component and components at harmonics of the horizontal scan frequency, each with a cluster about it of components separated at the vertical scan rate. Chrominance information is generally transmitted in the spectral gaps between these components. In the NTSC system, for example, two components of the chrominance signal, the in-phase (I) and quadrature (Q) signals, are amplitude modulated in quadrature to each other onto a subcarrier whose frequency (3.579545 MHz) has been selected to cause the resulting chrominance sidebands to fall in the spectral gaps between the luminance spectral components. The composite signal thus includes interleaved luminance and chrominance signals. The subcarrier frequency results in horizontal, vertical, and temporal interleaving so as to minimize mutual interference from cross-talk between the luminance and chrominance signals.

In typical video recording systems such as video cassette recorders (VCR's) used in the home for recording television signals, it is known, for the purpose of recording on a magnetic tape, to transpose the chrominance signal conventionally situated in the upper portion of the frequency spectral band of a composite television signal to a position in the spectral band below the luminance signal. Such a modulation or down conversion is commonly known in the recording art as a "color-under" recording system. In such a color-under system, the in-phase (I) and quadrature (Q) components of the

chrominance signal are processed conventionally, albeit at a different carrier frequency, to develop a color signal (C) for displaying a scene.

5 The well-known VHS system utilized in many VCR's produces degraded picture quality in comparison with, for example, properly received and processed broadcast television signals - because it does not provide the full necessary horizontal resolution. It has long been a goal of television engineers to find ways of transmitting more information in a channel of given bandwidth. The frame and line rates are generally fixed in accordance with standards, and therefore, a bandwidth limitation typically results in a reduction in horizontal resolution. The typical restricted bandwidth of, for example, the VHS system of about 2.0 to 2.5 MHz thus produces an image of inadequate horizontal resolution.

15 Various techniques are known for recording a full bandwidth signal on a limited bandwidth medium such as magnetic tape. Thus, commonly assigned pending U.S. patent application Serial No. 07/569,029, filed August 17, 1990 of Strolle et al., entitled AN IMPROVED VIDEO SIGNAL RECORDING SYSTEM (Samsung Docket No. 1020) and herein incorporated by reference, (corresponding to European Patent Application No. 91 307 342.5 - Publication No. 0 471 517) discloses such system. Furthermore, a number of prior U.S. patent applications and other publications are discussed in said application Serial No. (Docket No. P53184/DNC-90-084) of Strolle et al. Related subject-matter is also disclosed in the following patent applications, herein incorporated by reference: pending U.S. patent application Serial No. 07/562,907, filed August 6, 1990, of Ko et al., entitled IMPROVING THE REMOVAL OF THE FOLDING CARRIER AND SIDEBANDS FROM AN UNFOLDED VIDEO SIGNAL (Samsung, Docket No. 1004) (corresponding to GB Patent Application No. 91 09732.9 - Publication No. 2 246 926); pending U.S. patent application

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Serial No. 07/531,057, filed May 31, 1990 of Ko et al., entitled CONTROL
SIGNAL SPREADER (Samsung Docket No. 1009) (corresponding to GB
Patent Application No. 91 08683.5 - Publication No. 2 245 448); and pending
U.S. patent application Serial No. 07/531,070, filed May 31, 1990 of Strolle
5 et al., entitled COLOR-UNDER CHROMA CHANNEL ENCODED-WITH
AUXILIARY SIGNALS (Samsung Docket No. 1017) (corresponding to GB
Patent Application No. 91 08836.9 - Publication No. 2 244 888). Other
systems, such as, for example, that disclosed in U.S. patent No. 4,831,463,
issued May 16, 1989 to Faroudja, herein incorporated by reference, require
10 modification of the format such that a tape recorded in accordance with that
system would result in undesirable artifacts or defects in the picture when
played back on a standard unmodified VHS machine.

In a system such as that described in the aforementioned pending U.S.
15 patent application Serial No. 07/569,029, filed August 17, 1990 of Strolle et
al., entitled AN IMPROVED VIDEO SIGNAL RECORDING SYSTEM,
(Samsung Docket No. 1020), (corresponding to European Patent Application
No. 91 307 342.5 - Publication No. 0 471 517) backward compatibility is
available for video signals recorded in the improved (I-VHS) format and such
20 recorded signals can be played back on a standard VHS player. In setting up
system parameters, a compromise can be struck between the backward
compatibility which is often a desirable advantage and the picture quality
which may be somewhat compromised by artifacts under certain conditions.
Thus, the quality of the I-VHS picture is generally less than optimum possible
25 without constraints because of the need to provide backward compatibility.
Nevertheless, conditions may arise when one or the other of these two
conflicting requirements is the more important. For example, a user of a
camcorder may wish to decide that backward compatibility for playback on
a standard VHS machine, while nevertheless desirable and required, is not a
30 factor of such major importance in a particular application that it should be

allowed to compromise unduly a picture intended to be reproduced from the same recording medium on an I-VHS machine. Conversely, a user may wish to decide that a high degree of backward compatibility is so desirable in another particular application that the quality of reproduction when using an I-VHS machine need not be the utmost. However, in both instances, the user is constrained to accept the built-in engineering compromise the manufacturer has opted to design into the equipment as offering a generally acceptable solution under various conditions of use.

10 In accordance with an aspect of the invention, apparatus in a backward compatible video signal recording and playback system for recording a full bandwidth video signal on a limited bandwidth medium utilizing a luminance signal having high frequencies being folded into low frequencies and unfolded on playback includes circuitry for selecting a desired level of high frequency performance for a given degree of reverse compatibility and circuitry for recording a signal indicative of the level.

20 According to one aspect of the present invention, there is provided, in a backward compatible video signal recording and playback system for recording a full bandwidth video signal on a limited bandwidth medium utilizing a luminance signal having high frequencies being folded into low frequencies and subsequently unfolded on playback, a method for selecting a desired level of high frequency performance for a given degree of reverse compatibility, comprising the steps of:

- 25
- a. selecting a level for said high frequencies being folded;
 - b. recording a signal indicative of said level;
 - 30 c. sensing said signal on playback; and

- d. utilizing said signal as a control signal for compensating on playback for said level selected for said high frequencies.

Preferably, step a. is performed by selectively attenuating below a
5 normal level said high frequencies being folded.

Preferably, step a. is under user control.

Preferably, step b. is performed by encoding said signal into a data
10 stream being recorded on tape.

Preferably, step d. is performed by controlling a variable attenuator.

Preferably, step d. is selectively disabled and a predetermined
15 attenuation substituted therefor.

According to another aspect of the present invention, there is provided,
in a backward compatible video signal recording and playback system for
recording a full bandwidth video signal on a limited bandwidth medium
20 utilizing a luminance signal having high frequencies being folded into low
frequencies and subsequently unfolded on playback, apparatus for selecting a
desired level of high frequency performance for a given degree of reverse
compatibility, the apparatus comprising:

- 25 a. means for selecting a level for said high frequencies being folded;
- b. means for recording a signal indicative of said level;
- 30 c. means for sensing said signal on playback; and

- d. means for utilizing said signal as a control signal for means for compensating on playback for said level selected for said high frequencies.

5 Preferably, said means for selecting a level for said high frequencies being folded selectively attenuates below a normal level said high frequencies being folded.

10 Preferably, said means for selecting a level for said high frequencies being folded is under user control.

 Preferably, said means for recording a signal indicative of said level encodes said signal into a data stream being recorded on tape.

15 Such apparatus as above may include variable attenuator means, wherein said means for utilizing said signal as a control signal for compensating on playback for said level selected for said high frequencies controls said variable attenuator means.

20 Preferably, said means for utilizing said signal as a control signal for compensating on playback for said level selected for said high frequencies can be selectively disabled and a predetermined attenuation substituted therefor.

25 According to a further aspect of the present invention, there is provided, in a backward compatible video signal recording and playback system for recording a full bandwidth video signal on a limited bandwidth medium utilizing a luminance signal having high frequencies being folded into low frequencies and subsequently unfolded on playback, apparatus including:

means for selecting a desired level of high frequency performance for a given degree of reverse compatibility; and

means for recording a signal indicative of said level.

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Such apparatus as above may include means for selecting a level for said high frequencies being folded.

Such apparatus as above may include means for recording a signal
10 indicative of said level.

Such apparatus as above may include means for sensing said signal on playback.

15 According to another aspect of the present invention, there is provided a backward compatible video signal recording system for recording a full bandwidth video signal on a limited bandwidth medium, said system comprising:

20 encoding means for receiving a composite video signal and producing a luminance signal having attenuated high frequencies folded into low frequencies and a signal including a chrominance component and a motion component;

25 means coupled to said encoding means for recording said luminance signal;

means coupled to said encoding means for recording said chrominance and motion signal;

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user operable means coupled to said encoding means for selecting a level for said high frequencies being folded;

means coupled to said user operable means for applying for recording
5 a signal indicative of said level to one of said means for recording said luminance signal and said means for recording said chrominance and motion signal.

Preferably, said means for applying for recording applies said signal
10 indicative of said level to said means for recording said chrominance and motion signal.

Such a video signal recording system may comprise:

15 playback means for sensing said signal indicative of said level; and

means coupled to said playback means for utilizing said signal as a control signal for compensating on playback for said level selected for said high frequencies.

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According to a further aspect of the present invention, there is provided a video signal recording system for recording a full bandwidth video signal on a limited bandwidth medium along with a control signal indicative of a relative amplitude setting of a folded spectral portion of luminance high
25 frequencies, said system comprising:

encoding means for adaptively processing a composite video signal in response to a motion representative signal and producing first and second signals, said first signal being a luminance signal having a spectral portion of
30 luminance high frequencies having a relative amplitude setting and being

subsampled so as to be in folded into a spectral gap in the low frequencies,
and being bandwidth limited to the bandwidth of said limited bandwidth
medium, said second signal being a combined signal including a chrominance
component, a motion component, and a control signal component
5 representative of said relative amplitude setting; and

recording circuitry for recording said signals on said medium.

According to another aspect of the present invention, there is provided
10 a video playback system for reproducing a full bandwidth video signal
prerecorded on a limited bandwidth medium along with a control signal
representative of a relative amplitude setting of a folded spectral portion of
luminance high frequencies, said system comprising:

15 a luminance signal playback circuit for retrieving a prerecorded
luminance signal from said medium;

a chrominance signal playback circuit for retrieving a prerecorded
combined chrominance and motion signal from said medium; separator circuit
20 means coupled to said chrominance signal playback circuit for extracting said
motion signal and said chrominance signal from said combined chrominance
and motion signal; decoder means coupled to said separator circuit means for
retrieving said control signal;

25 unfolding circuit means for extracting said folded spectral portion of
luminance high frequencies and adaptively regenerating said full bandwidth
luminance signal in response to said motion signal; programmable attenuator
means coupled to said unfolding circuit means and being responsive to said
control signal for compensating for said relative amplitude setting of said
30 folded spectral portion of luminance high frequencies; and

means for combining said full bandwidth luminance signal with said extracted chrominance signal for reproducing said full bandwidth video signal prerecorded on said limited bandwidth medium.

5 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 a block schematic diagram of one example of recording
10 apparatus in accordance with an embodiment of the invention; and

Figure 2 is a block schematic diagram of one example of playback apparatus in accordance with an embodiment of the invention.

15 Figure 1 shows a portion of a record section of a video signal recorder. An input terminal 10 is coupled to a source, not shown, of a composite video signal. Input terminal 10 is coupled to an input terminal of an analog to digital converter (A/D) 12. An output terminal of A/D converter 12 is coupled to an input terminal of an adaptive luminance signal separator 14, the
20 input terminal of a motion signal separator 16, and the input terminal of a chrominance signal separator 18. An output terminal of adaptive luminance signal separator 14 is coupled to an input terminal of an adaptive folding circuit, generally indicated as 22 and to be described in greater detail further below. An output terminal of motion signal separator 16 is coupled to a
25 control input terminal of adaptive luminance signal separator 14 and to a motion signal input terminal of chrominance signal combining circuit 24. An output terminal of chrominance signal separator 18 is coupled to a chrominance signal input terminal of chrominance/motion signal combining circuit 24. An output terminal of chrominance/ motion signal combining
30 circuit 24 is coupled to a data input terminal of an encoder 26. An output of

encoder 26 is coupled to a digital to analog converter (D/A) 28. An output terminal of D/A converter 28 is coupled to an input terminal of a chrominance record circuit 30. An output of chrominance record circuit 30 is coupled to a record head 32. Record head 32 records a signal supplied to it on magnetic recording tape in a video cassette.

The output terminal of adaptive luminance signal separator 14 is coupled to an input terminal of a horizontal high pass filter (HPF) 34, an input terminal of a horizontal low pass filter (LPF) 36, a first data input terminal of a soft switch 38 and to a data input terminal of a programmable attenuator 40. An output of horizontal HPF 34 is coupled to an input terminal of a level detector 42. An output terminal of level detector 42 is coupled to a control input terminal of soft switch 38. An output terminal of horizontal LPF 36 is coupled to a second data input terminal of soft switch 38. The output of programmable attenuator 40 is coupled to a first terminal of a weighted adder 44 whose input signal applied at its first data terminal is weighted by $\frac{1}{2}$. An output terminal of soft switch 38 is coupled to a data input terminal of a modulator 46. A clock signal input terminal of modulator 46 is coupled to a source S_c of a folding carrier signal having a frequency of f_c . An output terminal of modulator 46 is coupled to a data input terminal of a programmable attenuator 48. The output of attenuator 48 is coupled to a second data input terminal of weighted adder 44, whose input signal applied at its second data terminal is weighted by $\frac{1}{2}$. An output terminal of weighted adder 44 is coupled to an input terminal of a low pass filter (LPF) 50. An output terminal of LPF 50 is coupled to the input of a D/A converter 52. The output of D/A converter 52 is coupled to a luminance record circuit 54, similar to such circuits found in present VCR's.

An output terminal of motion signal separator 16 is coupled to a control input terminal of adaptive luminance signal separator 14 and a motion signal

input terminal of a chrominance/motion signal combining circuit 24. An output terminal of chrominance/motion signal combining circuit 24 is coupled to an input terminal of an encoder 26. An output of chrominance record circuit 30 is coupled to record head 32.

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A user selectable code generator 56 has its output terminal coupled to an encoding input terminal of encoder 26, and to respective control inputs of attenuator 48 and attenuator 40.

10 The operation of the circuitry shown in the block diagram of Figure 1 will next be described. Further details on certain portions of the circuitry are described in the aforementioned pending U.S. patent application Serial No. 07/569,029, filed August 17, 1990 by Strolle et al. entitled AN IMPROVED VIDEO SIGNAL RECORDING SYSTEM (Samsung Docket No. 1020),
15 (corresponding to European Patent Application No. 91 307 342.5 - Publication No. 0 471 517).

The composite video signal input is converted by D/A 12 to a sampled data multibit digital composite video signal V. The sampling frequency is
20 selected in a manner more fully described below. For an NTSC signal, the sampling frequency may be selected to be about 10MHz, for example. Signal V is supplied to the adaptive luminance separator 14, which extracts the luminance component L, to the motion signal separator 16, which extracts a motion representative signal M, and to a chrominance signal separator 18,
25 which extracts the chrominance signal component.

The extracted luminance signal L is further processed by the adaptive folding circuit 22. This circuit folds attenuated high frequency components of the luminance signal L back into lower frequency components, and filters
30 the resulting signal so that all the information in the full-bandwidth luminance

signal L is contained in a folded luminance signal Lf which has a bandwidth of about 2.5 MHz. The adaptive folding circuit 22 will be described in more detail below. The folded luminance signal Lf is converted to an analog signal Lr in D/A 52. Thus, this signal is in a form in which it can be recorded on a video cassette by luminance recording circuitry 54.

The extracted motion signal M and the extracted chrominance signal C are combined into a single composite signal $C + M$ in the chrominance/motion signal combining circuit 24. The $C + M$ signal is converted into an analog signal by D/A 28. Thus, this signal is in a form in which it can be recorded on a video cassette by chrominance recording circuitry 30.

In the operation of the adaptive folding circuitry 22 shown in the block diagram of Figure 1, the combination of horizontal HPF 34, level detector 42, horizontal LPF 36 and soft switch 38 forms an adaptive depeaker which reduces the amplitude of the luminance high frequencies to a level such that if reproduced on a VCR which had no provision for removing them, the artifacts do not cause the reproduced picture to be unacceptable. The operation of the adaptive depeaker is described in detail in the aforementioned pending U.S. patent application Serial No. 07/569,029, filed August 17, 1990, by Strolle et al., entitled AN IMPROVED VIDEO SIGNAL RECORDING SYSTEM (Samsung Docket No. 1020), (corresponding to European Patent Application No. 91 307 342.5 - Publication No. 0 471 517).

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Briefly, horizontal HPF 34 extracts the high frequency luminance signal. The level of the luminance high frequencies is detected in the level detector 42. Level detector 42 operates in a known manner as an envelope detector to produce a signal which has the value of the maximum amplitude

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of the high frequency luminance signal. Soft switch 38 can be of a type such as that described in aforementioned pending U.S. patent application Serial No. 07/569,849, filed August 17, 1990 by Strolle et al., entitled AN IMPROVED VIDEO SIGNAL RECORDING SYSTEM (Samsung Docket No. 1020).

Horizontal LPF 36 produces a signal in which the luminance high frequencies are attenuated relative to the luminance low frequencies. When the level of luminance high frequencies, as detected by level detector 42, is zero or nearly zero, then the high frequencies do not need to be attenuated, and the output signal from soft switch 38 is completely from input terminal 505 carrying the unfiltered luminance signal L. As the level of luminance high frequencies increases, the luminance high frequencies need to be attenuated. In this situation, the proportion of unfiltered luminance signal L decreases in the output signal LD from the soft switch 38 and the proportion of low pass filtered luminance signal increases. When the level of luminance high frequencies is a maximum or nearly a maximum, then the high frequencies need to be attenuated to the maximum extent and the output signal LD from soft switch 38 is completely from the horizontal LPF 36.

The depeaked luminance signal LD is then modulated about a folding carrier having a frequency f_r in modulator 46. The folding frequency is selected so as to maximize the separation between the folding carrier and the baseband luminance signal in the temporal, vertical and horizontal directions.

The output of modulator 46 has a lower sideband containing a spectral image of the 4.2 MHz bandwidth depeaked signal but inverted in frequency. That is, the depeaked luminance signal is folded about the folding frequency f_r . Low depeaked baseband frequencies are folded into the vicinity of 5 MHz

and high depeaked baseband luminance frequencies of 4.2 MHz, for example, are folded into the vicinity of 800 kHz.

5 The output of modulator 46, i.e. the folded depeaked luminance signal, is then passed through a programmable attenuator 48 and thereafter to an input of a weighted adder 44. The baseband luminance signal is passed through a programmable attenuator 40 and applied to the other input of weighted adder 44 so as to be combined with the folded depeaked luminance signal to form a composite signal which is low pass filtered by low pass filter
10 50.

 Programmable attenuators 48 and 40 have their control inputs coupled to a user selectable code generator 56. The output of code generator 56 depends upon an input provided by a user and determines the attenuation
15 provided by attenuators 48 and 40. The attenuators are capable of positive and negative attenuation, that is they can boost as well as attenuate. Programmable attenuators 48 and 40 are controlled in a complementary manner, that is, when attenuator 48 exhibits high attenuation, then attenuator 40 exhibits low attenuation and vice versa. The actual values of attenuation
20 are predetermined such that at one extreme, the composite signal from adder 44 provides a I-VHS signal for recording that is highly backward compatible for playback on a standard VHS machine and at the other extreme, provides a I-VHS signal that takes advantage of the bandwidth capability of I-VHS so as to provide a high quality picture for playback on an I-VHS machine but is
25 less compatible for playback on a standard VHS machine.

 In a simple version of the present invention, these may be the only two options available. Thus, when attenuator 48 exhibits a relatively high attenuation and attenuator 40 exhibits a relatively low attenuation, the
30 recorded signal will be of a lesser quality but more backward compatible than

with the converse condition where the attenuation levels of attenuators 48 and 40 are interchanged.

In another version of the present invention, a plurality of options can be made available, representing a range of compromise values in between the extremes, as may be desired in various applications.

The output of user selectable code generator 56 is also applied to encoder 26 which correspondingly encodes, in a manner known per se, the chrominance/motion signal $C + M$ from signal combining circuit 24 before its application to D/A converter 28. Thus, information on the settings selected in the programming of attenuators 48 and 40 is recorded along with the $C + M$ signal for use during playback.

The folded depeaked luminance signal is then combined with the baseband luminance signal in weighted adder 44. This composite signal is then low pass filtered by LPF 50, which has a passband sufficiently narrow so as to eliminate all of the signal which would not pass through the narrow-band channel.

Figure 2 shows a schematic block diagram of a portion of an example of a playback section of a video signal recorder embodying the present invention. In reference to Figure 2, a playback head 60 is incorporated in a standard tape transport (not shown) of a VCR. Playback head 60 is coupled to respective input terminals of a luminance signal playback circuit 60 and a chrominance signal playback circuit 62. An output terminal of luminance signal playback circuit 60 is coupled to a first input terminal 64 of a decoder, generally indicated as 66, and an output terminal of chrominance signal playback circuit 62 is coupled to a second input terminal 68 of decoder 66.

In operation, playback head 60 supplies its signal to both the luminance playback circuit 60 and the chrominance playback circuit 62, in a known manner. The previously recorded folded luminance signal occupies a band of frequencies at around 1.4 - 5.9 MHz, and the previously recorded chrominance plus motion signal occupies a 1 MHz band of frequencies at around 629 kHz. The luminance playback circuitry processes the folded luminance signal in the usual manner to produce the playback folded luminance signal pb. The chrominance playback circuitry processes the chrominance plus motion signal to produce the playback chrominance plus motion signal $C + M_{pb}$. These signals are then processed by decoder 66 which extracts the motion signal from the chrominance signal and uses it to aid in unfolding the folded high frequency luminance component and reconstructing the full bandwidth luminance signal. The reconstructed full bandwidth luminance signal and the chrominance signals are then combined to form a composite video signal at a terminal 15.

Referring now to the circuitry of decoder 66 as shown in the block schematic diagram of Figure 2, input terminal 64 is coupled to an input terminal of a clamping circuit 70. An output terminal of clamping circuit 70 is coupled to an input terminal of an analog to digital converter (A/D) 72. An output of A/D 72 is coupled to an input terminal to a time base corrector (TBC) 74. An output terminal of TBC 74 is coupled to a data input terminal 76 of an adaptive unfolding circuit, generally indicated as 78. Input terminal 7G is coupled to an input terminal of a high Pass filter (HPF) 80 and to an input of a programmable attenuator 82. An output of programmable attenuator 82 is coupled to a first input terminal of an adder 84. An output terminal of adder 84 is coupled to an output terminal 86. An output terminal of HPF 80 is coupled to an input terminal of a modulator 88. An output terminal of modulator 88 is coupled to an input terminal of a vertical low pass filter (LPF) 90. An output terminal of vertical LPF 90 is coupled to an input

terminal of a second programmable attenuator E. An output terminal of programmable attenuator E is coupled to a second input terminal of adder 984. A second input terminal of modulator 88 is coupled to a source 94 of an unfolding carrier signal f_{ur} .

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Terminal 86 is coupled to respective input terminals of a temporal low pass filter LPF 96 and an adaptive spatial LPF 100. An output terminal of temporal LPF 96 is coupled to a first data input terminal of a soft switch 98. An output terminal of adaptive spatial LPF 100 is coupled to a second data
10 input terminal of soft switch 98. An output terminal of soft switch 98 is coupled to an input terminal of an adaptive peaker circuit 102. An output terminal of adaptive peaker 102 is coupled to the luminance signal input terminal of a composite video signal generator 104.

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An output terminal of chrominance signal playback circuit 62 is coupled to an input terminal of a clamping circuit 106. An output terminal of clamping circuit 106 is coupled to an input terminal of an analog to digital converter (A/D) 108. An output terminal of A/D 108 is coupled to an input
20 terminal of a time base corrector (TBC) 110. An output terminal of TBC 110 is coupled to an input terminal of a chrominance/motion signal separator 112. A first output terminal of the chrominance/motion signal separator 112 is coupled to a second input terminal of the composite video signal generator 104. A second output terminal of chrominance/motion signal separator 112 is coupled to a control terminal of soft switch 98. A third output terminal of
25 chrominance/motion signal separator 112 is coupled to an input terminal of a decoder 114. An output of decoder 114 is coupled to respective control inputs of programmable attenuator 92 and programmable attenuator 82. An output of a manual override control unit H is coupled to a control input of decoder 114.

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In operation of the system shown in Figure 2, the chrominance plus motion signal previously recorded on the cassette tape is a bidirectional signal, so the zero voltage of this signal is clamped to a digital signal of 128 out of 255 in clamping circuit 106. The A/D 108 produces a sampled multibit digital signal representing the chrominance plus motion signal and the TBC 110 operates to correct any timing inaccuracies in this signal, and produces the recovered chrominance plus motion signal $C + M^*$.

Phase inaccuracies due to the recording process may exist between the luminance and chrominance signals which are not compensated in the separate TBC's 74 and 110. Apparatus for restoring the proper phase relationship is described in patent application Serial No. 07/531,144, entitled APPARATUS FOR RESTORING THE CORRECT PHASE RELATION OF THE CHROMA AND LUMINANCE SIGNALS PASSED THROUGH SEPARATE PATHS, filed May 31, 1990 by Ko et al. (Samsung Docket No. 1014), which is herein incorporated by reference (corresponding to GB Patent Application No. 91 10020.6 - Publication No. 2 246 264) .

Chrominance/motion separator 112 processes the recovered chrominance plus motion signal $C + M^*$ to produce a recovered motion signal M^* which is supplied to the control input terminal of the adaptive unfolding circuit 78, and the chrominance signal C^* which is supplied to the chrominance signal input terminal of the composite video signal generator 104.

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The adaptive unfolding circuit 78 unfolds the luminance high frequencies which were previously folded into the luminance low frequencies, and restores the full bandwidth luminance signal L^* . This full bandwidth signal L^* is supplied to the luminance signal input terminal of composite video signal generator 104. Composite video signal generator 104 operates

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in a known manner to combine the luminance signal L^* and chrominance signal C^* to form a standard composite video signal. This signal may be used by equipment which utilizes such a signal, for example, a television receiver.

- 5 Signal Lf^* at terminal 76 is the limited bandwidth folded luminance signal. The horizontal HPF 80 filters out the frequencies below the folded luminance signal containing the chrominance information.

10 The demodulated signal from modulator 88 is filtered by vertical low pass filter 90 and coupled by way of programmable attenuator 92 to an input of an adder 984. The received folded luminance signal from TBC 74 is coupled by way of a programmable attenuator 82 to the other input of adder 984. The resulting unfolded signal Luf depends on the attenuator settings. Under the conditions of a normally recorded I-VHS signal, signal Luf consists
15 of a full bandwidth unfolded luminance signal centered around temporal, vertical and horizontal DC, and an image of the full bandwidth luminance signal centered on the unfolding carrier which is at one-half the maximum temporal frequency, one-half the maximum vertical frequency and at a horizontal frequency of about 5 MHz.

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Information relating to the attenuator settings optionally selected for use during the recording process is derived from the signal encoded along with the $C + M$ signal and obtained during playback in the form of a control signal CNTRL from decoder G, coupled to chroma/motion separator 112. This
25 control signal CNTRL is coupled to control inputs of attenuators 92 and 82 for setting their respective attenuation levels. These attenuation levels are arranged to compensate for the attenuator settings used during the recording process. Programmable attenuators 92 and 82 have positive and negative attenuation capability - that is, they can provide a boost as well an amplitude
30 reduction. Attenuators 92 and 82 respond in complementary fashion to the

CNTRL signal, so that the overall level remains reasonably flat over the spectral range.

5 A manual override control unit 116 allows a user to select an operational mode whereby decoder 114 sets the attenuation of attenuators 92 and 82 to default values that allow operation to be essentially in accordance with the original systems described in the aforementioned pending U.S. patent application Serial No. 07/569,029, filed August 17, 1990 by Strolle et al., entitled AN IMPROVED VIDEO SIGNAL RECORDING SYSTEM
10 (Samsung Docket No. 1020), (corresponding to European Patent Application No. 91 307 342.5 - Publication No. 0 471 517). In this operating mode, the system is unresponsive to the information relating to the attenuator settings optionally selected for use during the recording process and derived from the signal encoded along with the C + M signal and obtained during playback in
15 the form of a recovered control signal CNTRL from decoder 114.

Adaptive spatial LPF 100 operates adaptively to separate spatially the unfolded luminance signal Luf. Soft switch 98 controls the proportion of the temporally separated and adaptively spatially separated unfolded full
20 bandwidth luminance signals to be included in the unfolded luminance signal in response to the recovered motion control signal M*. When the level of motion is zero or nearly zero, the output of the soft switch 98 is completely from the temporal LPF 96. As the magnitude of motion gradually increases, the proportion of the input from the temporal LPF 96 decreases and the
25 proportion of the input from the adaptive spatial LPF 100 increases. In the presence of relatively high levels of motion, the output from the soft switch 98 is from the adaptive spatial LPF 100.

The output from soft switch 98 is a depeaked luminance signal.
30 Adaptive peaker 102 is used to boost the attenuated luminance high

frequencies to restore them to the original level before the attenuation. The output of adaptive peaker 102 is then applied to one of the inputs of composite generator 104 which provides the composite video output referred to above.

5 Further details on certain portions of the circuitry are described in the aforementioned pending U.S. patent application Serial No. 07/569,029, filed August 17, 1990 by Strolle et al., entitled AN IMPROVED VIDEO SIGNAL RECORDING SYSTEM (Samsung Docket No. 1020), (corresponding to European Patent Application No. 91 307 342.5 - Publication No. 0 471 517).

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 Illustratory embodiments of the present invention have been described by way of example. Various modifications and changes may be carried out without departing from the invention.

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 Furthermore, where the chroma subcarrier is encoded with phase relationships that are different from the VHS system forming the context of the described embodiments, such in the PAL and Beta formats, the present invention is adaptable with appropriate adjustment of the subcarrier phases utilized. Furthermore, while the system has been described in terms suitable
20 for in relation to the NTSC system, it is clearly applicable to other systems with different standards. While digital signal processing has been shown, various functions can be equivalently carried out in analog technology.

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 These and other modifications will be apparent to those skilled in the art and are intended to be within the scope of the invention.



CLAIMS:

1. In a backward compatible video signal recording and playback system for recording a full bandwidth video signal on a limited bandwidth medium
5 utilizing a luminance signal having high frequencies being folded into low frequencies and subsequently unfolded on playback, a method for selecting a desired level of high frequency performance for a given degree of reverse compatibility, comprising the steps of:
 - 10 a. selecting a level for said high frequencies being folded;
 - b. recording a signal indicative of said level;
 - c. sensing said signal on playback; and
 - 15 d. utilizing said signal as a control signal for compensating on playback for said level selected for said high frequencies.
2. A method in accordance with claim 1, wherein step a. is performed by
20 selectively attenuating below a normal level said high frequencies being folded.
3. A method in accordance with claim 1 or 2, wherein step a. is under
25 user control.
4. A method in accordance with claim 1, 2 or 3, wherein step b. is performed by encoding said signal into a data stream being recorded on tape.
5. A method in accordance with claim 1, 2, 3 or 4, wherein step d. is
30 performed by controlling a variable attenuator.



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6. A method in accordance with claim 1, 2, 3 or 4, wherein step d. is selectively disabled and a predetermined attenuation substituted therefor.

7. In a backward compatible video signal recording and playback system for recording a full bandwidth video signal on a limited bandwidth medium utilizing a luminance signal having high frequencies being folded into low frequencies and subsequently unfolded on playback, apparatus for selecting a desired level of high frequency performance for a given degree of reverse compatibility, the apparatus comprising:

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a. means for selecting a level for said high frequencies being folded;

b. means for recording a signal indicative of said level;

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c. means for sensing said signal on playback; and

d. means for utilizing said signal as a control signal for means for compensating on playback for said level selected for said high frequencies.

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8. Apparatus in accordance with claim 7, wherein said means for selecting a level for said high frequencies being folded selectively attenuates below a normal level said high frequencies being folded.

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9. Apparatus in accordance with claim 7 or 8, wherein said means for selecting a level for said high frequencies being folded is under user control.



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10. Apparatus in accordance with claim 7, 8 or 9, wherein said means for recording a signal indicative of said level encodes said signal into a data stream being recorded on tape.
- 5 11. Apparatus in accordance with claim 7, 8, 9 or 10, including variable attenuator means, wherein said means for utilizing said signal as a control signal for compensating on playback for said level selected for said high frequencies controls said variable attenuator means.
- 10 12. Apparatus in accordance with claim 7, 8, 9 or 10, wherein said means for utilizing said signal as a control signal for compensating on playback for said level selected for said high frequencies can be selectively disabled and a predetermined attenuation substituted therefor.
- 15 13. In a backward compatible video signal recording and playback system for recording a full bandwidth video signal on a limited bandwidth medium utilizing a luminance signal having high frequencies being folded into low frequencies and subsequently unfolded on playback, apparatus including:
- 20 means for selecting a desired level of high frequency performance for a given degree of reverse compatibility; and
- means for recording a signal indicative of said level.
- 25 14. Apparatus in accordance with claim 13, including means for selecting a level for said high frequencies being folded.
15. Apparatus in accordance with claim 14, including means for recording a signal indicative of said level.



16. Apparatus in accordance with claim 15, including means for sensing said signal on playback.

17. A backward compatible video signal recording system for recording a
5 full bandwidth video signal on a limited bandwidth medium, said system comprising:

encoding means for receiving a composite video signal and producing
a luminance signal having attenuated high frequencies folded into low
10 frequencies and a signal including a chrominance component and a motion component;

means coupled to said encoding means for recording said luminance
signal;

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means coupled to said encoding means for recording said chrominance
and motion signal;

user operable means coupled to said encoding means for selecting a
20 level for said high frequencies being folded;

means coupled to said user operable means for applying for recording
a signal indicative of said level to one of said means for recording said
luminance signal and said means for recording said chrominance and motion
25 signal.

18. A video signal recording system in accordance with claim 17, wherein
said means for applying for recording applies said signal indicative of said
level to said means for recording said chrominance and motion signal.



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19. A video signal recording system in accordance with claim 17 or 18, comprising:

5 playback means for sensing said signal indicative of said level; and

means coupled to said playback means for utilizing said signal as a control signal for compensating on playback for said level selected for said high frequencies.

10 20. A video signal recording system for recording a full bandwidth video signal on a limited bandwidth medium along with a control signal indicative of a relative amplitude setting of a folded spectral portion of luminance high frequencies, said system comprising:

15 encoding means for adaptively processing a composite video signal in response to a motion representative signal and producing first and second signals, said first signal being a luminance signal having a spectral portion of luminance high frequencies having a relative amplitude setting and being subsampled so as to be in folded into a spectral gap in the low frequencies,
20 and being bandwidth limited to the bandwidth of said limited bandwidth medium, said second signal being a combined signal including a chrominance component, a motion component, and a control signal component representative of said relative amplitude setting; and

25 recording circuitry for recording said signals on said medium.

21. A video playback system for reproducing a full bandwidth video signal prerecorded on a limited bandwidth medium along with a control signal representative of a relative amplitude setting of a folded spectral portion of
30 luminance high frequencies, said system comprising:



a luminance signal playback circuit for retrieving a prerecorded luminance signal from said medium;

5 a chrominance signal playback circuit for retrieving a prerecorded combined chrominance and motion signal from said medium; separator circuit means coupled to said chrominance signal playback circuit for extracting said motion signal and said chrominance signal from said combined chrominance and motion signal; decoder means coupled to said separator circuit means for retrieving said control signal;

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unfolding circuit means for extracting said folded spectral portion of luminance high frequencies and adaptively regenerating said full bandwidth luminance signal in response to said motion signal; programmable attenuator means coupled to said unfolding circuit means and being responsive to said control signal for compensating for said relative amplitude setting of said folded spectral portion of luminance high frequencies; and

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means for combining said full bandwidth luminance signal with said extracted chrominance signal for reproducing said full bandwidth video signal prerecorded on said limited bandwidth medium.

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22. A video signal recording and/or reproducing apparatus substantially as hereinbefore described with reference to Figure 1 and/or Figure 2 of the accompanying drawings.

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