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ADAPTIVE Y/C SEPARATION APPARATUS
FOR TV SIGNALS

This invention relates to an apparatus for separating the luminance and chrominance components Y and C from a composite video signal in a television receiver. It will be described with reference to the NTSC system, by way of example.

In a color television (TV) system (such as NTSC), the luminance and chrominance components ("luma" and "chroma", respectively) of a composite color television signal are disposed within the video frequency spectrum in a frequency interleaved relation, with the luma components at integral multiples of the horizontal line scanning frequency and the chroma components at odd multiples of one-half the line scanning frequency. In the NTSC system, the upper portion (i.e., about 2.1 to 4.2 MHz) of the video frequency spectrum (0 to 4.2 MHz) is shared by chroma components and high frequency luma components. The lower portion (below about 2.1 MHz) of the video frequency spectrum is occupied solely by luma components. Various comb filter arrangements for separating the frequency interleaved luma and chroma components of the video signal are known, for example, U. S. Patents 4,143,397 (Holmes) and 4,096,516 (Pritchard).

Comb filters operate on the premise that the composite video signal from horizontal-line-to-horizontal-line or field-to-field or frame-to-frame is highly correlated. When this assumption fails, as it frequently does with program video, certain anomalies occur in the reproduced images. The anomalies result from imperfect cancellation of chroma in the luma output, and vice versa. For example, if there is an abrupt change in the amplitude of chroma between adjacent lines, scintillating serrations will occur along the horizontal edges displayed in the image for a line comb filtered (hereinafter "combed") signal. These serrations (called "hanging dots") are due to incompletely cancelled chroma in the luma channel. Alternatively, if there is an abrupt change in the luma amplitude between horizontal lines,

1 anomalous color saturation effects will be displayed along
horizontal edges. Similar undesirable effects occur in
the field and frame combed signals.

Adaptive comb filters eliminate some of these
5 artifacts caused by imperfect cancellation of chroma in
the luma output, and vice versa. The adaptive comb
filters typically use alternate Y/C separation functions
(e.g., 1-H line comb, 2-H line comb, etc.) and, for each
of these functions, calculate an index of correctness.
10 The Y/C separation function with the best index is
selected for generating the combed luma and chroma
components. U. S. Patents 4,050,084 (Rossi) and 4,636,840
(McNeely et al.) disclose illustrative Y/C separation
systems having adaptive features.

15 In the Rossi's adaptive Y/C separation apparatus,
the incoming (or undelayed) composite video signal B is
bandpass filtered (hereinafter "bandpassed") to pass a
band of frequencies (about 2.1 to 4.2 MHz) including the
interleaved chroma components and the high frequency luma
20 components. The bandpassed incoming composite video
signal B_b is delayed twice by two, 1-H delay lines to
develop a pair of bandpassed, 1-H delayed and 2-H delayed
composite video signals M_b and T_b respectively. The
capital letters "B", "M" and "T", respectively, stand for
25 the bottom, middle and top horizontal lines of the video
signal, and the subscript "b" represents a bandpassed
signal.

Rossi uses a plurality of comparators to compare
the three bandpassed composite video signals B_b , M_b
30 and T_b (i.e., undelayed, 1-H and 2-H delayed signals,
respectively). Depending upon the outcome of the
comparison, one of several Y/C separation functions (e.g.,
1-H comb, 2-H comb, etc.) is selected to the exclusion of
others to develop a bandpassed chroma signal C_b .

35 The incoming composite video signal B is applied
to a third 1-H delay line to develop a 1-H delayed
(non-bandpassed) composite video signal M. The bandpassed
chroma signal C_b is subtracted from the 1-H delayed

1 (non-bandpassed) composite video signal M to generate the luma signal Y, having an uncombed low frequency portion (below 2.1 MHz) and a combed high frequency portion (between 2.1 and 4.2 MHz).

5 One of the limitations of Rossi is that he employs arbitrary reference values, which makes the effectiveness of his apparatus variable with signal conditions. Another limitation of Rossi is that his decision process compares single samples from each of the
10 lines (to decide which Y/C separation function is best), and is, thus, susceptible to errors due to noise.

Still another limitation is that Rossi uses three (3) 1-H delay lines for generating the four signals (B_b , M_b and T_b and M) needed to develop the separated luma
15 and chroma components Y and C_b . Delay lines are relatively expensive to implement, both in analog and digital domains (but, particularly, in the digital domain). A further limitation of Rossi is that he uses an "all-or-nothing" selection process. (One of the Y/C
20 separation functions is used to the exclusion of all others.)

The adaptive Y/C separation apparatus disclosed in U. S. Patent 4,636,840 (McNeely et al.) overcomes some of the aforesaid limitations of Rossi. Pairs of composite
25 video signals are developed, which are delayed from each other by an integral number of horizontal line periods (e.g., 1H, 263H, 525H, etc.). Each pair of video signals is used to generate separated luma and chroma components Y and C, and an index ("sum of cross differences") that
30 measures the correctness of the accompanying Y and C components. These measures of correctness are compared. Depending upon the results of comparison, the Y and C components associated with the best measure of correctness are selected for further processing in the TV receiver.

35 McNeely et al. do not rely on arbitrary reference values, thereby providing a more accurate Y/C separation. Furthermore, McNeely et al. use a pair of samples (instead of a single sample) from each of the lines for calculating

1 cross differences, thereby increasing noise immunity of
the selection process. However, McNeely et al. use an
"all-or-nothing" selection process similar to Rossi.

Another limitation of McNeely et al. is that
5 their separated luma component is subjected to a "combing"
effect over its entire band (0 to 4.2 MHz). The combing
action over the high frequency band portion of the video
frequency spectrum (which is shared with chroma
components) has the desired effect of deleting chroma
10 components from the luma output. Extension of this
combing action into the low frequency band portion (which
is not shared with the chrominance signal components),
however, is not needed to effect the desired removal of
chroma components, and serves only to unnecessarily delete
15 luma components. Components in the lower end (e.g., below
about 1 MHz) of the unshared band which are subject to
such deletion are representative of "vertical detail" luma
information. Preservation of such vertical detail is
desirable to avoid loss of vertical resolution in the luma
20 content of the displayed image.

The present invention discloses an improved Y/C
separation apparatus of the adaptive type. The subject
apparatus includes means coupled to the incoming composite
25 video signal B for producing (1) a non-bandpassed
once-delayed composite video signal M, (2) a bandpassed
incoming composite video signal B_b , (3) a bandpassed
once-delayed composite video signal M_b and (4) a
bandpassed twice-delayed composite video signal T_b .

30 A control circuit coupled to receive the three
bandpassed composite video signals B_b , M_b and T_b
provides a signal K for controlling the relative weights
assigned to the three bandpassed signals in a manner that
reduces cross contamination of the separated components.

35 A combining circuit coupled to receive the respective
bandpassed composite video signals B_b , M_b and T_b and
responsive to the control signal K develops a combed
chroma signal C_b , where:

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$$C_b = 1/2 M_b - 1/2 [K.T_b + (1-K).B_b] \quad \dots(1)$$

The luma signal Y is derived by subtracting the combed chroma signal C_b from the once-delayed (non-bandpassed) composite video signal M, i.e.,

5

$$\begin{aligned} Y &= M - C_b \\ &= M_1 + M_b - 1/2 M_b + 1/2 [K.T_b + (1-K).B_b] \\ &= M_1 + 1/2 M_b + 1/2 [K.T_b + (1-K).B_b], \quad \dots(2) \end{aligned}$$

where the subscript "1" represents low frequency components.

10

In the accompanying drawings:

FIGURE 1 is a block diagram representation of an adaptive Y/C separation apparatus in accordance with the principles of the present invention;

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FIGURE 2 shows a circuit, in block form, for generating a sampling clock signal SCS for use in the apparatus of FIGURE 1;

FIGURE 3 illustrates, in a block diagram form, the circuit employed for developing a control signal K for use in the FIGURE 1 apparatus;

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FIGURES 4 and 5 graphically represent diagonally-separated, video signal samples involved in the estimation of the control signal K; and

25

FIGURE 6 is a block diagram representation of a mixing circuit responsive to the control signal K for use in the FIGURE 1 apparatus.

In the drawings, the lines interconnecting various blocks represent either single conductor connections carrying analog signals or multi-conductor buses carrying multi-bit parallel binary digital signals, as the case may be.

It will be readily appreciated by those skilled in the TV signal processing art that the invention may be practiced on either digital or analog representations of the composite video signal. For the purposes of the detailed description, however, it will be assumed herein that the composite video signal is an 8-bit binary digital signal and that the composite video signal is in the NTSC format.

1 Referring to FIGURE 1, an adaptive Y/C separation
apparatus, pursuant to the subject invention, is
designated by a numeral 10. As shown therein, an incoming
or undelayed composite video signal B from the output 12
5 of a video detector stage (not shown) in the TV receiver
is applied to an analog-to-digital (A/D) converter 14.
The A/D converter 14 translates the incoming composite
video signal B into a digital signal comprising successive
8-bit samples or words in response to a sampling clock
10 signal SCS. As previously indicated, the capital letters
"B", "M" and "T" stand for the bottom, middle and the top
horizontal video lines as displayed on the kinescope, and
the subscript "b" stands for a bandpassed signal.

It is assumed herein that the sampling clock
15 signal SCS has a frequency (i.e., about 14.3 MHz) that is
four (4) times the frequency F_{sc} (i.e., 3.58 MHz) of the
color subcarrier signal CSS (a burst of which is
transmitted during the horizontal blanking interval), and
is phase locked therewith. In FIGURE 2, a functional
20 block 16 represents the clock signal source, which in
response to the color subcarrier signal burst develops the
 $4 F_{sc}$, phase-locked sampling clock signal SCS. It will
be understood that all the functional elements shown in
FIGURES 1, 3 and 6 are timed by the sampling clock signal
25 SCS.

The incoming digital composite video signal B at
the output of the A/D converter 14 is applied to a first
bandpass filter 18 and a first 1-H delay element 20. The
bandpass filter 18 is operative to pass a band of
30 frequencies (e.g., about 1 to 4.2 MHz) including the
shared upper region (i.e., about 2.1 to 4.2 MHz) of the
video frequency spectrum. The bandpassed incoming
composite video signal at the output of the bandpass
filter 18 is identified as B_b . U. S. Patent 4,524,423
35 (Acampora) describes an illustrative digital bandpass
filter circuit.

The 1-H delay element 20 delays the incoming
composite video signal B by one horizontal line scanning

1 period to develop a once-delayed (non-bandpassed)
composite video signal M. The once-delayed composite
video signal M is coupled to a second bandpass filter 22,
which has the same passband as the first bandpass filter
5 18 (i.e., about 1 to 4.2 MHz). The bandpassed
once-delayed composite video signal at the output of the
second bandpass filter 22 is labeled as M_b . A second
1-H delay element 24 delays the bandpassed once-delayed
composite video signal M_b by one horizontal line period
10 to produce a bandpassed twice-delayed composite video
signal T_b .

In the embodiment described herein and shown in
FIGURE 1, the incoming (non-bandpassed) composite video
signal B and the bandpassed once-delayed composite video
15 signal M_b are each delayed by one horizontal line period
(1H) by the respective delay elements 20 and 24.
Alternately, the video signals B and M_b may be delayed
by any suitable integral number of horizontal line
periods. For example, for a field comb arrangement, the
20 1-H delay elements 20 and 24 are replaced by elements that
delay the respective input signals by one field period
(i.e., 263H). For a frame comb arrangement, the
respective signals are delayed by one frame period (i.e.,
525H).

25 It is noted that the first delay element 20 has a
passband (e.g., 0 to 4.2 MHz) that allows the incoming
non-bandpassed composite video signal B to pass through
without significant distortion. On the other hand, the
second delay element 24 has a passband (e.g., 1 to 4.2
30 MHz) that can pass the bandpassed once-delayed composite
video signal M_b . It means that a simpler, relatively
inexpensive configuration may be used for the second delay
element 24, vis-a-vis the first delay element 20.

The three bandpassed signals B_b , M_b and T_b
35 (i.e., incoming, once-delayed and twice-delayed signals,
respectively) are coupled to a control signal generating
circuit 26. The circuit 26 develops a signal K that
controls the relative mixing of the three bandpassed

1 signals B_b , M_b and T_b such that the contamination of
the separated chroma signal by the high frequency luma
components is held to a minimum. The construction and
operation of the control signal generating circuit 26 will
5 be described in detail in conjunction with FIGURE 3.

The non-bandpassed once-delayed composite video
signal M is coupled to a combining circuit 28 along with
the three bandpassed signals B_b , M_b and T_b . The
combining circuit 28, responsive to the mixing control
10 signal K, generates the separated luma and chroma signals
Y and C_b in the manner described in detail hereinbelow.

The combining circuit 28 comprises a mixing
circuit 30 (also known as a "soft switch"), a subtracter
32, a divider 34 and another subtracter 36. The mixing
15 circuit 30 is coupled to receive the bandpassed incoming
and twice delayed composite video signals B_b and T_b .
Responsive to the control signal K, the mixing circuit 30
develops a weighted bandpassed composite video signal
 W_b , where

20
$$W_b = K.T_b + (1-K).B_b \quad \dots(3)$$

The subtracter 32 subtracts the weighted
composite video signal W_b from the bandpassed
once-delayed composite video signal M_b to develop an
output signal, which is divided by a factor of 2 to
25 generate a normalized chroma signal C_b . (See EQUATION
1.)

The second subtracter 36 subtracts from the
non-bandpassed once-delayed composite video signal M the
bandpassed chroma signal C_b to produce the separated
30 luma signal Y. (See EQUATION 2.) The combed chroma
signal C_b is applied to a third bandpass filter 38 to
further limit the frequencies in the chroma channel to a
range extending from about 3.1 to 4.1 MHz (i.e., about
3.58 $\pm$ 0.5 MHz). Digital-to-analog (D/A) converters 40
35 and 42, responsive to the clock signal SCS, translate the
digital luma and chroma signals into their analog
counterparts for further processing.

It is noted from EQUATION 2 that the separated

1 luma signal Y is combed only in the upper region (i.e.,
about 1.0 to 4.2 MHz) of the video frequency spectrum
where the high frequency luma and chroma components are
interleaved. The luma signal Y is, however, left intact
5 (i.e., not combed) in the lower frequency region (e.g.,
below 1.0 MHz) where only the vertical detail is present.

In the FIGURE 1 apparatus, appropriate matching
delays 42, 44, 46 and 48 are inserted to compensate for
the delay variations in the different signal paths.

10 The principles underlying the generation of the
mixing control signal K will be first explained with
reference to FIGURES 4 and 5. The actual circuit for
producing the mixing control signal K will be later
described with reference to FIGURE 3.

15 FIGURE 4 represents a waveform diagram of
portions of three horizontal lines, which are separated by
an integral number of horizontal line periods (i.e., 1H,
263H, 525H, etc.). If an interline comb filter is
employed for separating the luma and chroma signals Y and
20 C_b , the three lines are three successive horizontal
lines in one image field. If an interfield comb filter is
used the three lines are separated by 263 horizontal
lines. In an interframe comb filter, the three lines are
separated by 525 horizontal lines.

25 The video signal is drawn as a sinusoid to
represent the relative phase of a chroma signal (of a
particular color) between lines. The signal is assumed to
be sampled at four times the chroma subcarrier rate with
representative sampling points designated +, 0, -, 0, +,
30 etc. The (+) points designate sampling instants at the
positive and negative phase excursions of the chroma
signal. The 0 points designate sampling points at the
zero crossings. However, the 0 sampling points do not
necessarily have zero values since the composite video
35 signal is the sum of chroma and luma signals. Nor is it
necessary that sampling be performed at the phases shown.
FIGURE 5 corresponds to FIGURE 4 with the waveforms
eliminated for purposes of clarity. In both FIGURES 4 and

1 5, the small letters a,b,c,d,e...h,j,k,l,m...and v,w,x,y
and z represent the intensity (or amplitude) values of the
picture elements (or pixels) from the three lines
designated as T_b , M_b and B_b (i.e., twice delayed,
5 once delayed and undelayed video signals, respectively).

In the comb filtering process, the horizontal
lines with antiphase chroma are subtractively combined to
produce the separated chroma signal C (with energy
concentrated at odd multiples of one-half the horizontal
10 line scanning frequency). If the amplitude of the luma
signal Y is identical between the lines combined, the luma
signal is completely cancelled by the subtraction
process. However, if the amplitude of the luma signal
differs between lines, the amount of cancellation of the
15 undesired luma signal Y in the separated chroma signal
 C_b is incomplete.

An estimation of how much weight is to be given
to the pixels from each of the lines is determined by a
comparison process. This is done by calculating a first
20 pair of cross differences CD_1 and CD_2 using a set of
four pixels (i.e., pixels j,y and l,w) from the two lines
defined by the bandpassed undelayed and once-delayed video
signals B_b and M_b . The pixel pairs j,y and l,w have
like sampling phases (e.g., both positive or negative
25 phases with respect to the color subcarrier) and are
disposed symmetrically on the opposite sides (i.e., left
and right) of the pixel of interest (i.e., k). EQUATIONS
for CD_1 and CD_2 are:

$$CD_1 = j - y \quad \dots(4)$$

30 $CD_2 = l - w \quad \dots(5)$

A second pair of symmetrically-disposed cross
differences CD_3 and CD_4 is determined similarly by
using another set of four pixels (i.e., l,b and j,d) from
the two lines formed by the bandpassed once-delayed and
35 twice-delayed video signals M_b and T_b , respectively.

EQUATIONS for CD_3 and CD_4 are:

$$CD_3 = j - d \quad \dots(6)$$

$$CD_4 = l - b \quad \dots(7)$$

1 To calculate the control signal K, the absolute values of the first pair of cross differences CD_1 and CD_2 are determined, and the maximum value MAX_1 between the two is established. Thus,

5 $MAX_1 = MAX. (|CD_1|, |CD_2|) \dots(8)$

Similarly, another maximum value MAX_2 is computed as follows:

$MAX_2 = MAX. (|CD_3|, |CD_4|) \dots(9)$

The control signal quotient K_q is determined from the following EQUATION:

$$K_q = \frac{MAX_1}{MAX_1 + MAX_2} \dots(10)$$

If MAX_1 and MAX_2 are both equal to zero, then K_q is set equal to 1/2.

The quotient K_q is then quantized into 33 different levels (i.e., 32 steps) to define the digital control signal K applied to the mixing circuit or soft switch 30, as indicated above.

20 The mixing circuit 30 is so arranged that the larger the control signal K the higher the weight given to the pixel c from the top line T_b . Thus, if $MAX_1 \gg MAX_2$, the pixel c from the top line T_b will be given the weight of one and the pixel x from the bottom line B_b will be given the weight of zero. At the other extreme, if $MAX_1 \ll MAX_2$, the pixel c will be the weight of zero and the pixel x will be given the weight of one.

30 Because the estimation signal is determined with reference to two groups of four samples each (e.g., j,y,l,w and j,d,l,b), its sensitivity to noise is reduced with respect to a two sample estimate. Conversely, it is more sensitive to the occurrence of diagonal images, and, therefore, it produces more desirable responses along reproduced diagonal lines.

35 The operation of the control signal generating circuit 26 will now be explained in conjunction with FIGURE 3. A first set of pixels y, l and d representative of the signals B_b , M_b and T_b respectively appear at

1 the input terminals 60, 62 and 64 of the circuit 26. The terminals 60, 62 and 64 are coupled to the respective connections in FIGURE 1. A second set of pixels w , j and b representative of 2-pixel delayed versions of the
 5 respective signals B_b , M_b and T_b appear at the outputs of the second 1-pixel delay elements 72, 76 and 80. Subtracters 82, 84, 86 and 88 calculate the respective cross differences CD_1 ($j-y$), CD_2 ($1-w$), CD_3 ($j-d$) and CD_4 ($1-b$). The four cross differences
 10 CD_1 , CD_2 , CD_3 and CD_4 are applied to the circuit elements 92, 94, 96 and 98 to determine their respective absolute values.

The circuit elements 102 and 104 coupled to receive the respective pairs of absolute values $|j-y|$,
 15 $|1-w|$ and $|j-d|$, $|1-b|$ determine the two maximum values MAX_1 and MAX_2 as follows:

$$MAX_1 = \text{MAX.} (|j-y|, |1-w|) \quad \dots(11)$$

$$MAX_2 = \text{MAX.} (|j-d|, |1-b|) \quad \dots(12)$$

An adder 106 adds the two maximum values MAX_1
 20 and MAX_2 to form the denominator of the quotient K_q . The value MAX_1 (which defines the numerator of the quotient K_q) and the sum $MAX_1 + MAX_2$ are passed through respective lowpass filters 106 and 108 to eliminate high frequency variations. The transfer
 25 function TF for the two lowpass filters 106 and 108 is identical and is given by the following EQUATION:

$$TF = 1/8 (1+Z^{-1})(1+Z^{-2})(1+Z^{-3}), \quad \dots(13)$$

where Z^{-1} , Z^{-2} and Z^{-3} represent one, two and three
 30 pixel delays and Z is the conventional Z-transform variable.

The outputs of the two lowpass filters 106 and 108 are applied to a divider 110, which develops the quotient K_q . This quotient K_q is then quantized into 33 different levels (32 steps) and made available as the
 35 control signal K at an output terminal 112 for application to the soft switch 30.

FIGURE 6 is a schematic block diagram representation of the mixing circuit 30. The output

1 $T_b - B_b$ of a subtracter 120 is multiplied by the factor
K in a multiplier 122. An adder 124 combines the output
K . $(T_b - B_b)$ of the multiplier 122 with the signal B_b
to produce the weighted video signal W_b at an output
5 terminal 126, where:

$$W_b = K.T_b + (1-K).B_b \quad \dots(14)$$

The weighted video signal W_b is subtracted from
the bandpassed once-delayed video signal M_b , and the
resulting signal is divided by a factor of 2 to produce
10 the bandpassed chroma signal C_b as previously
described. (See EQUATION 1.)

The disclosed and claimed apparatus is applicable
to PAL systems. The difference between the NTSC system
and PAL system is that the lines of video to be combined
15 in the PAL system to generate combed signals must be
separated an integral multiple of two lines. For a line
comb filter, the appropriate video signal lines employed
in the PAL system are lines $n-2$, n and $n+2$.

In the following claims the term "cross
20 difference" is defined as the difference (e.g., $j-y$)
between diagonally separated samples (e.g., j and y) from
different video lines (e.g., line M_b and B_b) separated
by an integral number (e.g., $1H$) of horizontal lines, and
disposed on the opposite sides of the sample of interest
25 (e.g., k). The samples (e.g., j and y) from which the
cross difference (e.g., CD_1) is developed are disposed
on either side (i.e., left and right) of the pixel (e.g.,
 k) for which separated luma and chroma signals Y and C are
currently being developed.

30 While a particular embodiment of the present
invention has been shown and described in detail,
adaptations and modifications will be apparent to one
skilled in the art.

CLAIMS:

1. In a color television system subject to reception of an incoming composite video signal B consisting of digital samples occurring synchronously with a sampling clock signal SCS; said composite video signal having given horizontal line scanning frequency (f_H), and being inclusive of a luminance component Y and a modulated subcarrier chrominance component C sharing an upper region of the video frequency spectrum in a frequency interleaved relationship; an apparatus for separating said luminance and chrominance Y and C of said composite video signal comprising:

means coupled to receive said incoming composite video signal B for producing the following signals:

- a non-bandpassed once-delayed composite video signal M ;
- a bandpassed incoming composite video signal B_b ;
- a bandpassed once-delayed composite video signal M_b ; and
- a bandpassed twice-delayed composite video signal T_b ;

said separating apparatus characterized by:

means coupled to receive said bandpassed incoming and once-delayed composite video signals B_b and M_b for determining a first pair of cross differences CD_1 and CD_2 between pairs of diagonally separated digital samples having like sampling phases and being symmetrically disposed on the opposite sides of a sample of interest;

means coupled to receive said bandpassed once-delayed and twice-delayed composite video signals M_b and T_b for determining a second pair of cross differences CD_3 and CD_4 between pairs of diagonally separated samples having like sampling phases and being symmetrically disposed on the opposite sides of said sample of interest; and

means coupled to receive said first pair of cross differences CD_1 and CD_2 for determining their respective absolute values $|CD_1|$ and $|CD_2|$;



means coupled to receive said absolute values $|CD_1|$ and $|CD_2|$ of said first pair of cross differences CD_1 and CD_2 for determining the maximum absolute value MAX_1 thereof;

means coupled to receive said second pair of cross differences CD_3 and CD_4 for determining their respective absolute values $|CD_3|$ and $|CD_4|$;

means coupled to receive said absolute values $|CD_3|$ and $|CD_4|$ of said second pair of cross differences CD_3 and CD_4 for determining the maximum absolute value MAX_2 thereof;

means for producing a signal K to control the relative mixing of said bandpassed composite video signals B_b , M_b and T_b by dividing one of said maximum absolute values MAX_1 and MAX_2 by the sum $(MAX_1 + MAX_2)$ thereof; and

combining means coupled to receive said non-bandpassed once-delayed composite video signal M and said bandpassed incoming, once-delayed and twice-delayed composite video signals B_b , M_b and T_b and responsive to said control signal K for generating at least one separated component signal.

2. Apparatus defined in Claim 1 wherein said combining means comprises:

mixing means coupled to receive said bandpassed incoming and twice-delayed composite video signals B_b and T_b and responsive to said control signal K for producing a bandpassed weighted composite video signal W_b , where

$$W_b = K.(T_b) + (1-K).(B_b); \text{ and}$$

means for subtractively combining said bandpassed once-delayed composite video signal M_b and said bandpassed weighted composite video signal W_b for generating a bandpassed chrominance component representative signal $2C_b$, where:

$$2C_b = M_b - W_b.$$



3. Apparatus defined in Claim 2 wherein said combining means further includes means for dividing the output of said subtractively combining means by a factor of two to generate a normalized chrominance component signal C_b .

4. Apparatus defined in Claim 3 wherein said combining means additionally includes means for subtractively combining said non-bandpassed once-delayed composite video signal M and said bandpassed chrominance component C_b to generate said luminance component Y, where

$$Y = M - C_b.$$

5. Apparatus for separating luminance and chrominance components of a composite video signal, substantially as hereinbefore described with reference to the accompanying drawings.

