

SIGNAL PROCESSING SYSTEM

The present invention relates to signal processing systems, and is concerned particularly with digital image processing systems.

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In conventional digital image processing systems using a standard signal, the frequency band of a luminance signal is 4.2MHz, while those of chrominance signals R-Y and B-Y are 1.3 and 0.5MHz, respectively. The luminance signal is added to an original signal after compensation of its horizontal-contour and the chrominance signals are band-amplified and next demodulated, where band-amplification gain is determined by an automatic chrominance gain controller, depending on the demodulated chrominance signals. The processed luminance and chrominance signals are mixed again at a matrix part and next displayed on a screen.

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With low frequency bands of image signals, however, high frequency components are not processed sufficiently due to the difference of transition time resulting from level difference, thereby degrading resolution.

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Preferred embodiments of the present invention aim to solve these problems and to provide a signal processing system for improving resolution by extending the horizontal frequency bands of separated luminance and chrominance signals and compensating the contour of an input image signal.

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According to a first aspect of the present invention, there is provided a digital image processing system comprising:

a luminance crispener for reducing transition time and extending frequency band of an input luminance signal;

5 a horizontal contour compensator for compensating horizontal contour of said input luminance signal;

a gray controller for amplifying a low level component of said input luminance signal;

10 luminance signal mixing means for mixing the output signals from said luminance crispener, said horizontal contour compensator and said gray controller and providing them in one line;

15 an automatic chrominance gain controller for amplifying and maintaining only the level of the input chrominance signal constant;

20 a demodulator connected to an output terminal of said automatic chrominance gain controller for converting the chrominance signal of constant level to a digital signal and demodulating it by a 1H (H : one period of horizontal scanning line) delayed burst signal;

a tint controller connected to an output terminal of said demodulator for controlling the tint of the demodulated chrominance signal;

25 a chrominance crispener connected to the output terminal of said tint controller for reducing the transition time and extending the frequency band of the controlled chrominance signal; and

a chrominance multiplexer connected to an output terminal of said chrominance crispener for multiplexing an output signal in one line after receiving output signals in two lines from said chrominance crispener.

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:

10 Figure 1 is a block diagram of one example of a signal processing system according to the present invention; and

Figures 2A - 2H are detailed circuit diagrams of examples of major parts of the signal processing system of Figure 1.

15 The signal processing system of Figure 1 comprises a luminance processing part 1000 for amplifying low level components of an input luminance signal after reducing transition time and compensating horizontal contour, and a chrominance processing part 2000 for extending frequency band of an input chrominance signal.

20 To describe in more detail, the luminance signal processing part 1000 comprises a luminance crispener 100 for reducing the transition time and extending the frequency band of the luminance signal, a horizontal contour compensator 200 for compensating the horizontal contour of the input
25 luminance signal, a gray controller 300 for amplifying the low level component of the input luminance signal, and a luminance signal mixer 400 for mixing and providing output signals in one line after receiving the output

signals from the luminance crispener 100, the horizontal contour compensator 200, and the gray controller 300.

5 The chrominance signal processing part 2000 comprises an automatic chrominance gain controller 500 for maintaining the level of the input chrominance signal constant, a demodulator 600 connected to an output terminal of the automatic chrominance gain controller 500, for converting the chrominance signal of constant level to a digital signal and demodulating it by
10 a 1H (H: one period of horizontal scanning line) delayed burst signal, a tint controller 700 connected to an output terminal of the demodulator 600 for controlling the tint of the demodulated chrominance signal, a chrominance crispener 800 connected to the output terminal of the tint controller 700 for reducing the transition time and extending the frequency band of the controlled chrominance signal, and a chrominance multiplexer 900 connected
15 to an output terminal of the chrominance crispener 800 for multiplexing the output signal from the chrominance crispener 800 from two lines into one line.

20 Figure 2 shows detailed circuit diagrams of each block in the image processing system of Figure 1, wherein Figure 2A shows the luminance crispener 100 in the luminance signal processing part 1000, Figure 2B shows the horizontal contour compensator 200 in the luminance signal processing part 1000, Figure 2C shows the gray controller 300 in the luminance signal processing part 1000, Figure 2D shows the automatic chrominance gain controller 500 in the chrominance signal processing part 2000, Figure 2E
25 shows the demodulator 600 in the chrominance signal processing part 2000, Figure 2F shows the tint controller 700 in the chrominance signal processor 2000, and Figure 2G shows the chrominance crispener 800 in the

chrominance signal processor 2000. Further, Figures 2H-a and 2H-b are respective detailed circuit diagrams of the luminance signal mixer 400 in the luminance signal processing part 1000 and the chrominance multiplexer 900 in the chrominance signal processing part 2000.

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In the luminance crispener 100 of the luminance signal processing part 1000, a second differentiator 102 for detecting rising and falling edges is connected to a first differentiator 101 for detecting the contour of a separated luminance signal YS, and a signal detector 103 for detecting an absolute value
10 is connected to an output terminal of the second differentiator 102 as shown in Figure 2A.

Also, a comparator 104 is connected to the output terminal of the signal detector 103 so as to provide an output signal from the signal detector 103
15 directly, when the output signal of the signal detector 103 is larger than a luminance control signal YSC. On the other hand, if the level of the output signal from the second differentiator 102 is low, it is applied to an amplifier 105 so that its level is magnified by a factor of 2.

20 The output signal from the comparator 104 and the output signal of the amplifier 105 are connected to input terminals of a multiplexer 106. Subsequently, a reference and code generator 107 is connected to the multiplexer 106 to generate and digitalize a reference signal according to a luminance limit control signal YLC.

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Another signal detector 108 for detecting the absolute value of the detected contour signal is connected to the output terminal of the first differentiator 101. A re-normalizer 109 is also connected to an output

terminal of this signal detector 108 for normalizing the detected signal once more. Another multiplexer 110 is connected to both output terminals of the reference and code generator 107 and the re-normalizer 109 for selecting and providing one of them through an output terminal. An amplifier 111 is
5 connected to both output terminals of the multiplexer 110 and a luminance gain control signal YGC.

In the contour compensator 200 of the luminance signal processing part 1000, noise removing cores 204, 205, and 206 are respectively connected to
10 band-pass filters 201, 202, and 203 for filtering the separated luminance signal YS, as shown in Figure 2B. Gain controllers 207, 208, and 209 for magnifying gains of an emphasized frequency band are connected to the output terminals of the noise removing cores 204, 205 and 206. Limiters
15 210, 211, and 212 for preventing degradation of a screen due to over-emphasis are respectively connected to the output terminals of the gain controllers 207, 208, and 209. An adder 213 is connected to the output terminals of the limiters 210, 211, and 212. Further, an overflow limiter 214 for limiting the added signal to 8-bit is connected to an output terminal of the
adder 213.

20 As shown in Figure 2C, in the gray controller 300 of the luminance signal processing part 1000, an adder 302 is connected to an output terminal of a low-pass filter 301 for detecting the average level of the separated luminance signal, to add a maximum luminance level YPC. An amplifier 303
25 for multiplying a reference gray gain value GGR is connected to the output terminal of the adder 302 and a limiter 304 is connected to amplifier 303 to prevent over-amplification.

The output signal P1 from the luminance crispener 100 shown in Figure 2A, the output signal P2 from the horizontal contour compensator 200 shown in Figure 2B, the output signal P3 from the gray controller 300 shown in Figure 2C, and the separated luminance signal P4 are all applied to the mixer 400 in the luminance signal processing part 1000.

As shown in Figure 2H-a, the mixer 400 includes a multiplier 401 for transmitting two-input signals P2, P3, a mixer 402 connected to receive the output of the mixer 400 and the signals P1 and P4, for transmitting the respective output signals P1 ~ P3 and the separated luminance signal P4 commonly in one line, and a black level limiter 403 connected to the output terminal of the mixer 402 for limiting the black level of the input signal according to a black level limit enable signal PBLE.

In the automatic chrominance controller 500 as shown in Figure 2D, a self-limiter 502 is connected to an amplifier 501 to limit over-amplified signals.

The demodulator 600 shown in Figure 2E is connected to this self-limiter 502.

In this modulator 600, a delay 601 for delaying the digitalized burst signal BS by 1H is connected to a delay controller 602 to synchronize the delayed signal with its original signal. A band-pass filter 603 for removing direct current DC component is connected to the output terminal of this delay controller 602. Also, a delay circuit 606 is connected to band-pass filter 603 to delay an output signal of the band-pass filter 603. A multiplier 607 is connected to the output terminal of this delay circuit 606 for amplifying the

output signal P5 from the self-limiter 502 in the automatic chrominance gain controller 500. A low-pass filter 608 for removing the doubled burst signal is connected to an output terminal of multiplier 607. Here, the output signal P6 from the low-pass filter 608 is a red chrominance signal R-Y. An adder 604 adds the output of band-pass filter 603 with the signal P5, and passes the output to a low-pass filter 605. The output signal P7 from the low-pass filter 605 is a blue chrominance signal B-Y.

The output signals P6 and P7 from the modulator 600 are fed back to the automatic chrominance gain controller 500 in Figure 2D and provided to adders 503 and 504, respectively, to be summed up during the period of a burst flag pulse BFP. Output terminals of the adders 503 and 504 are connected to signal detectors 505 and 506 for calculating and providing the absolute values to an adder 507 for adding the detected absolute values.

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A comparator 508 is connected to the output terminal of the adder 507 for comparing automatic chrominance reference signal ACCR, an automatic chrominance holding range signal ACCW and the output signal from the adder 507 to provide counting signals. Subsequently, a counter 509 is connected to the output terminal of the comparator 508 to count the output signals of the comparator 508. Then, the input chrominance signal is multiplied by the output signal of the counter 509, thereby being amplified.

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In Figure 2F, the output signals P6 and P7 of the low-pass filters 608 and 605 are applied to amplifiers 701-704 for amplifying the signals P6 and P7 according to tint control signals HUE1-HUE4 in the tint controller 700. An adder 705 is connected to the output terminals of the amplifiers 701 and 702, and another adder 706 is connected to the output terminals of the

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amplifiers 703 and 704. Overflow limiters 707 and 708 are connected to the adders 705 and 706, respectively, thereby preventing the overflow of the added signals.

5 Multiplexer 801 in the chrominance crispener 800 is connected to the output terminals of the overflow limiters 707 and 708 in the tint controller 700, as shown in Figure 2G, so that one of two chrominance signals P8 and P9 is selected corresponding to the doubled burst signal 2Fsc and provided through an output terminal. A first differentiator 802 is connected to the
10 multiplexer 801, thereby normalizing its output signal.

A re-normalizer 803 connected to the first differentiator 802 delays the output signal from the first differentiator 820 by 4H and compares the delayed signal with the undelayed signal, thereafter providing a minimum value when
15 the compared result is positive and a maximum value when the delayed compared result is negative. An absolute value detector 804 is connected to the re-normalizer 803 and four amplifiers 805 ~ 808 are connected to the output terminal of this absolute value detector 804 to provide amplification gains of 1, 0.5, -0.5, -1, respectively.

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On the other hand, a first differentiator 809 of first-order is connected to an output terminal of the re-normalizer 803. A reference and code generator 811 is connected to the output terminal of this differentiator 809 and generates codes according to the output signal of a multiplexer 810 which
25 transmits one of two limit reference signals RLC and BLS for the red and blue chrominance signals. The output signals of the amplifiers 805-808 are applied to a multiplexer 812 for selecting one of them according to an output signal from the reference and code generator 811. Also, an amplifier 814 for

amplifying the output from a multiplexer 813 is connected to the multiplexer 812 to transmit one of gain control signals RGC and BGC for red and blue colour-difference signals.

5 A delay controller 815 is connected to the output terminal of the multiplexer 801 to synchronize the delayed signal with the original signal, i.e., the undelayed signal. Also, an adder 816 is connected to both the amplifier 814 and the delay controller 815 and thereby their output signals are added to each other. The output signal from the adder 816 is applied to a
10 demultiplexer 817 for providing chrominance signals P₁₀ and P₁₁ to chrominance multiplexer 900.

As shown in Figure 2H-b, the output terminals of the demultiplexer 817 are respectively connected to adders 901 and 902 where the outputs from
15 the demultiplexer 817 are added to a chrominance offset reference signal COR, and the outputs from these adders 901 and 902 are applied to a multiplexer 904 for selecting and providing one of the outputs from the adders 901 and 902 according to the output signal from a NOR gate 903 or the quadrupled burst signal 4Fcs. Here, the NOR gate 903 provides the
20 combined signal of input control signals PBLK and Kill.

In the embodiment of the invention as described hereinabove, if the separated luminance signal YS is applied to the input terminal in Figure 2A, it is normalized by the first differentiator 101 in the luminance crispener 100
25 and next its rising and falling edges are detected by the second differentiator 102. The absolute value of the output signal from the second differentiator 102 is detected by the signal detector 103 and compared with the luminance control signal YSC at the comparator 104.

According to the compared result, one of the two inputs of the multiplexer 106 is selected and transmitted. In other words, if the absolute value of the output signal from the second differentiator 102 is larger than the YSC signal, the output signal from the second differentiator 102 is directly provided through the multiplexer 106. But, if the absolute value of the output from the second differentiator 102 is smaller than the YSC signal, the output from the second differentiator 102 amplified by the amplifier 105 is provided through the multiplexer 106. Then, the output signal from the multiplexer 106 is changed to a certain code according to the luminance limit control signal YLC.

The absolute value of the output signal of the first differentiator 101 is also detected by the signal detector 108 and amplified by the re-normalizer 109, where the gain of the re-normalizer 109 is selected among $-A$, $-0.5A$, $0.5A$, and A . Either the output signal from the re-normalizer 109 or the output signal from the reference and code generator 107 is selected by the multiplexer 110 and provided to the multiplier 111. Thus, the output signal from the multiplexer 110 is multiplied according to the luminance gain control signal YGC.

The separated luminance signal YS is filtered by the band-pass filters 201 ~ 203 in the horizontal contour compensator 200 in Figure 2B and each filtered signal corresponding to the pass frequencies of the band-pass filters 201 ~ 203 is applied to the noise removing cores 204 ~ 206. The outputs from the cores 204 ~ 206 are amplified by the gain controllers 207 ~ 209, respectively. The output signals from the gain controllers 207 ~ 209 are limited by the limiters 201 ~ 212 to prevent degradation due to the over-amplification.

The separated luminance signal applied to the horizontal contour compensator 200 passes the band-pass filters 201 ~ 203 for detecting and emphasizing the contour signal corresponding to the pass-band of the filters 201 ~ 203, thereby preventing degradation of the image due to over-emphasis.

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The luminance signal YS is also applied to the low-pass filter 301 in the gray controller 300 in Figure 2C for detecting its average level. The detected average luminance level is added to the maximum luminance level YPC by the adder 302 and amplified according to the gray gain reference signal GGR. The output from the multiplier 303 is limited by the limiter 304 to prevent degradation due to over-amplification.

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The output signal P1 from the multiplier 111 in the luminance crispener 100 shown in Figure 2A, the output signal P2 from the limiter 214 in the horizontal contour compensator 200 in Figure 2B, the output signal P3 from the limiter 304 in the gray controller 300, and the input luminance signal YS are commonly applied to the mixing block 402 in the mixer 400, as shown in Figure 2H-a.

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They are mixed with each other according to the blanking signal PBLK. The black level of the mixed signals is limited according to the black level limit enable signal PBLE. The transition time of the luminance signal is reduced by the luminance crispener 100 in Figure 2A and the horizontal contour is compensated by the horizontal contour compensator 200. If the level of the luminance signal is low, it is amplified by the gray controller 300 in Figure 2C. Subsequently, the output signals from each part in Figures 2A ~ 2C are mixed by the mixer 400 in Figures 2H-2a.

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The input chrominance signal CS is applied to the amplifier 501 in Figure 2D to be properly multiplied by one of the demodulated chrominance signal, the automatic color reference signal ACCR, and the automatic chrominance holding range signal ACCW, so that white noise is minimized.

- 5 The output signal from the amplifier 501 is limited by the limiter 502 to prevent degradation due to over-amplification. Subsequently, the limited output signal is applied to the demodulator 600.

- 10 The digitalized burst signal BS applied to the demodulator 600 in Figure 2E is 1H-delayed by the delay circuit 601 and this delayed signal is synchronized with its original undelayed signal by the delay controller 602. The direct current DC component of the output signal from the delay controller 602 is removed by the band-pass filter 603. This signal with no direct current DC component is multiplied by the signal P5 from the limiter
- 15 502 in Figure 2D by the amplifiers 604 and 607. The output signal from the amplifiers 604 and 607 are filtered by the low-pass filters 605 and 608, respectively, thereby removing their burst signal components $2F_{sc}$. The output signals P6 and P7 from the low-pass filters 608 and 605 are applied to the adders 503 and 504 where the applied signals P5 and P6 are continuously
- 20 added during the burst flag pulse period, respectively.

- Next, the absolute values of the output signals from the adders 503 and 504 are detected by the signal detectors 505 and 506, respectively. The output signals from the signal detectors 505 and 506 are added to each other
- 25 by the adder 507. Subsequently, the output signal from the adder 507 is applied to the comparator 508 to be compared with the automatic chrominance reference signal ACCR and the automatic chrominance holding range signal ACCW and then counted up or down. If the output signal from the adder 507

is smaller than both ACCR and ACCW signals, the comparator 508 generates an up-signal, while if it is larger than ACCR and ACCW signal, the comparator 508 generates a down-signal.

5 In order to prevent hysteresis, also, the up/down signal is provided only when it is continuously generated during four horizontal scanning lines 4H. The counter 509 counts the output signal from the comparator 508. The output signal from the counter 509 is applied to the amplifier 501 as a chrominance gain signal. As shown in Figure 2E, the gain of the
10 chrominance signal CS determines the magnitude according to the output signals of the low-pass filters, if the burst of the chrominance signal is constantly maintained and according to the determined gain, the constant chrominance signal is provided from Figure 2D.

15 The output signals P6 and P7 provided from the demodulator 600 are also applied to the tint controller 700. In other words, the output signals P6 and P7 of the demodulator 600 are applied to the multiplier 701 ~ 704 in Figure 2F and multiplied by the tint control signals HUE1 ~ HUE4. To explain in more detail, the red chrominance signal P6 is amplified by the tint
20 control signals HUE1 and HUE4, and the blue chrominance signal P7 is also amplified by the tint control signals HUE2 and HUE3.

 The red chrominance signal amplified in the multiplier 701 and the blue chrominance signal amplified in the multiplier 702 are added by the adder 705
25 and the added signal is applied to the limiter 707 to prevent over-amplification. Also, the blue chrominance signal amplified in multiplier 703 and the red chrominance signal amplified in multiplier 704 are added by the adder 706 and the added signal is applied to limiter 708 to prevent over-

amplification. Consequently, the tint of the red and blue chrominance signals P6 and P7 is controlled by the tint controller 700.

The chrominance signals P8 and P9 provided from the tint controller 700 in Figure 2F are applied to the chrominance crispener 800 shown in Figure 2G. Then, the horizontal contour of the chrominance signals is compensated and the frequency band is extended up to 3.58MHz. The chrominance signals P8 and P9 are provided from the tint controller 700, and one of them is transmitted by the multiplexer 801 and differentiated by the differentiator 802. The output signal from the differentiator 802 is delayed by the re-normalizer 803 and next compared with its original signal.

If the compared result is positive, the minimum value is selected and if the compared result is negative, the maximum value is selected. Then, the absolute value of the output from the re-normalizer 803 is detected by the signal detector 804 and next amplified by the amplifiers 805 ~ 808 with gains of 1, 0.5, -0.5, and -1.

The output signal from the re-normalizer 803 is differentiated by the differentiator 809 and next applied to the reference and code generator 811 so as to be changed to the code according to either the red chrominance limited reference signal BLC or the blue chrominance limit reference signal BLC transmitted through the multiplexer 810. One of the output signals of the amplifiers 805 ~ 808 is selected by the multiplexer 812 according to the code signal from the reference and code generator 811 and subsequently applied to the multiplier 814, and therefore, it is multiplied by one of the red chrominance gain control signal RGC and the blue chrominance gain control signal BGC selected by the multiplexer 813.

The output signal from the multiplexer 801 is delayed by the delay controller 815 so as to be synchronous with the output signal from the amplifier 814. Next, the delayed signal and the output signal from the multiplier 814 are added with each other by the adder 816 and applied to the demultiplexer 817, thereby providing signals P10 and P11 according to the doubled burst signal 2Fsc.

These signals P10 and P11 provided from the chrominance crispener 800 in Figure 2G are applied to the chrominance multiplexer 900 in Figure 2H-b. The signals P10 and P11 are added to the chrominance offset reference signal COR by the adders 901 and 902. The output signals from the adders 901 and 902 are applied to the multiplexer 904 so that one of them is selected according to the output signal from the NOR gate 903 which combines the blanking signal PBLK with the white and/or black detecting signal KILL and provided as the processed chrominance signal CP.

As described above, the transition time of the luminance signal YS is reduced and the frequency band is extended by the luminance crispener 100. By the horizontal contour compensator 200, the contour signal which is sensed at the boundary region and can bring about the level transition is compensated by being added to the original signal.

Furthermore, the low level component of the luminance signal YS is added to the original signal by the gray controller 300 and next, if its peak value is smaller than the reference signal value, the peak value is amplified. The output signals from the luminance crispener 100, the horizontal contour compensator 200 and the gray controller 300 and the input luminance signal

YS are mixed with each other by the mixer 400 and provided as a processed luminance signal.

5 The input chrominance signal CS is constantly maintained by the amplifier 501 of which the amplification gain is determined by the red and blue chrominance signals P6 and P7 separated by the demodulator 600. The constantly maintained chrominance signal is again applied to the demodulator 600 and separated to the red and blue chrominance signals P6 and P7 i.e. R-Y and B-Y.

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The tint of the separated signals P6 and P7 is controlled by the tint controller 700 and the controlled tint is applied to the chrominance crispener 800. Thus, the frequency bands of the chrominance signals are extended. The frequency-extended signals P10 and P11 are applied to the chrominance
15 multiplexer 900 and provided through one terminal as the processed chrominance signal CP.

As described hereinabove, the horizontal contour of the input luminance signal is compensated and the frequency band is extended by the luminance
20 signal processing means. Also, the frequency band of the input chrominance signal is extended by the chrominance signal processing means. By the extension of frequency band, the transition time of the high frequency-components of the image signal is reduced and also the resolution is improved. Thus, the illustrated signal processing system is suitable for high
25 frequency image signal processing and has a short data processing time.



CLAIMS

1. A digital image processing system comprising:

5 a luminance crispener for reducing transition time and extending frequency band of an input luminance signal;

a horizontal contour compensator for compensating horizontal contour of said input luminance signal;

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a gray controller for amplifying a low level component of said input luminance signal;

luminance signal mixing means for mixing the output signals from said

15 luminance crispener, said horizontal contour compensator and said gray controller and providing them in one line;

an automatic chrominance gain controller for amplifying and maintaining only the level of the input chrominance signal constant;

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a demodulator connected to an output terminal of said automatic chrominance gain controller for converting the chrominance signal of constant level to a digital signal and demodulating it by a 1H (H : one period of horizontal scanning line) delayed burst signal;

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a tint controller connected to an output terminal of said demodulator for controlling the tint of the demodulated chrominance signal;



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a chrominance crispener connected to the output terminal of said tint controller for reducing the transition time and extending the frequency band of the controlled chrominance signal; and

5 a chrominance multiplexer connected to an output terminal of said chrominance crispener for multiplexing an output signal in one line after receiving output signals in two lines from said chrominance crispener.

2. A signal processing system substantially as hereinbefore described with
10 reference to Figure 1 of the accompanying drawings.

3. A signal processing system substantially as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.

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