

WHITE-BALANCING CIRCUIT

The present invention relates to a white-balancing circuit for automatically adjusting white balance - for example, in a video camera.

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There has been developed an automatic white-balancing circuit for a video camera for processing analogue signals, and such a circuit has been put to practical uses. However, even though the adjustment of white balance in a video camera is desirable for a video camera processing digital signals, an automatic white-balancing circuit for a digital processing video camera has not been developed so far, there having been difficulties encountered in processing photographed video signals to digital signals.

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Preferred embodiments of the present invention aim to overcome the above described difficulties and to provide an automatic digital white-balancing circuit for a video camera for processing digital signals, in which white balance can automatically be adjusted so as to enable the manufacture of a totally digitalized video camera.

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According to the present invention, there is provided an automatic digital white-balancing circuit comprising:

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means for receiving colour-separated digital signals;

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means for receiving and carrying out an evaluation of colour-difference signals generated from said colour-separated digital signals and a luminance digital signal; and

means for adjusting the gain of at least some of said colour-separated digital signals in response to said evaluation, to obtain a desired white balance.

5 The circuit may further comprise:

multipliers for multiplying colour-separated digital signals based on multiplying coefficients;

10 a colour-difference matrix for matrixing the outputs of said multipliers to output R-Y and B-Y colour-difference signals;

an encoder for encoding a Y signal and said output R-Y and B-Y colour-difference signals from said colour-difference matrix;

15 sampling means for sampling said Y signal and said R-Y and B-Y colour-difference signals from said colour-difference matrix at a sampling frequency fSPL;

20 integrating memory means for integrating the data sampled from said sampling means and storing said data into respective addresses corresponding to picture division;

comparing means for deciding whether integrated data is included in a
25 white balance adjusting region; and

a microcomputer for receiving decision signals from said comparing means for designating addresses in said integrating memory means and to

5 receive said integrated colour-difference signals for applying multiplying coefficients to said multipliers in order to adjust the white balance.

The circuit may further comprise:

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B-Y' generating means and R-Y' generating means for mixing and amplifying the colour-separated digital R,B signals and said Y signal to generate B-Y' and R-Y' signals and apply them to said comparing means; and

10 switching means for being driven by the output decision signals from said comparing means to apply said sampled data from said sampling means to said integrating memory means.

The circuit may further comprise:

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latching means for integrating and temporarily storing said sampled data from said sampling means;

20 memory groups for storing said sampled data into picture-divided memories by controlling the driving of said latching means according to the output from said comparing means; and

25 registers for storing the addresses of said memory groups and evaluating the read data to apply said multiplying coefficients from said microcomputer through an internal bus to said multipliers.

The circuit may further comprise:

integrators for integrating said sampled output data from said sampling means;

5 memories for storing the integrated data of said integrators corresponding to n divisions of a picture; and

10 comparing and integrating means for reading out the stored data of said memories at addresses supplied from said microcomputer and carrying out integration and comparison of said read data to apply the data to said microcomputer.

15 In another aspect, an automatic digital white-balancing circuit according to the present invention comprises sampling means for sampling Y signals and R-Y, B-Y colour-difference signals from a colour-difference matrix after receipt of separated R,G,B signals, integrating memory means for integrating data sampled by the sampling means and summing up and storing the data corresponding to pictures, comparing means for deciding whether the integrated input data from the integrating memory means is included in a white balance adjusting region, and white balance adjusting means for
20 receiving decision signals from the comparing means by a MICOM (microcomputer) for comparing the data read out from an address of the integrating memory means and providing multiplying coefficients to multipliers.

25 The invention extends also to a video camera provided with an automatic digital white-balancing circuit according to any of the preceding aspects of the invention.

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:

5 Figure 1 is a graph showing a colour-temperature track and a white detecting region in a preferred embodiment of the present invention;

Figure 2 is a graph showing the detection of luminance signals for obtaining the detecting region of Figure 1;

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Figure 3 illustrates one example of an automatic digital white-balancing circuit according to the present invention;

15 Figure 4 illustrates a preferred embodiment of an automatic digital white-balancing circuit according to the present invention;

Figure 5 illustrates another embodiment of a circuit according to the present invention; and

20 Figure 6 illustrates still another embodiment of a circuit according to the present invention.

In the figures, like reference numerals denote like or corresponding parts.

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Figure 2 illustrates the detection of a luminance Y signal at a predetermined level for obtaining the detecting region as shown in the graph of colour-temperature track, in Figure 1. The circuit of Figure 3 comprises multipliers 1, 2, 3 for multiplying colour-separated R, G, B digital signals.

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Multipliers 1 and 3 multiply the colour-separated R, G, B digital signals by respective multiplying coefficients output from a MICOM 9. The circuit of Figure 3 also comprised a colour-difference matrix 4 for combining and separating Y signals and outputs from the multipliers 1, 2, 3 to output R-Y, B-Y colour-difference signals. An encoder 5 encodes the Y signals and the R-Y, B-Y colour-difference signals from the colour-difference matrix 4 to output the Y signals and colour signals C. A sampling part 6 samples the Y signals and the R-Y, B-Y colour-difference signals from the colour-difference matrix 4 at a suitable sampling frequency fSPL, and an integrating memory part 7 integrates and computes output data from the sampling part 6 to store the output data into respective addresses of the memory corresponding to picture divisions. A comparing part 8 decides whether the integrated data of the integrating memory part 7 is included in a white balance adjusting region, and a MICOM 9 programmed for designating an address within the integrating memory part 7 according to the input of a decision signal from the comparing part 8 applies white balance adjusting multiplying coefficients to the multipliers 1, 3 according to the output of R-Y and B-Y data from the integrating memory part 7.

Figure 4 shows an embodiment similar to the circuit of Figure 3 and further comprising an R-Y' generating part 12 and a B-Y' generating part 11 for generating R-Y' signals and B-Y' signals respectively after mixing and amplifying Y signals and the separated R, B colour-difference signals from the R-Y' generating part 12 and the B-Y' generating part 11 to decide whether the R-Y' and B-Y' colour-difference signals are included in the white balance region, and a switching part 10 for applying to the integrating memory part 7 data sampled in the sampling part 6 and being driven according to decision signals of the comparing part 8.

The circuit of the embodiment of Figure 5 comprises a comparing part 8 for deciding whether the Y signals and the sampled R-Y, B-Y colour-difference signals of the sampling part 6 are included in the white balance adjusting region, latching parts 16, 17 driven according to decision signals of the comparing part 8 for integrating and passing only data included in the white balance adjusting region, memories 18, 19 for storing the passed data from the latching parts 16, 17 into a memory corresponding to the picture division, and a MICOM 9 for applying the white balance adjusting multiplying coefficients to multiplier registers 13, 15, after reading the stored data in the memories 18, 19 into the designated address to be compared and computed. There is also a multiplier register 14 for multiplier 2.

Figure 6 is a variant of the circuit shown in Figure 5, wherein the circuit comprises integrators 21, 22, 23 for integrating the respective data of the R-Y, Y and B-Y signals sampled in the sampling part 6, memories 24, 25, 26 for storing the data output from the integrators 21, 22, 23 corresponding to N divisions of a picture, and a comparing and integrating part 27 for summing up and transferring the divided data to the MICOM 9 by comparing the data and deciding whether the data is included in the white balance adjusting region after reading out the data stored in the memories 24, 25, 26 according to addresses designated by the MICOM 9.

In the drawings, reference number 20 indicates an internal bus.

Examples of operation of the above-described examples of automatic digital white-balancing circuits according to the present invention will now be described in more detail.

The graph of Figure 1 shows the colour-temperature track and the white detecting region as a comparison of the R-Y and B-Y colour-difference signals. Unlike the human eye, a camera cannot discriminate colours and therefore, a white level is divided by the colour-difference signals.

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As shown in the graphical illustration of Figure 1, it is assumed that the y-axis represents an R-Y colour-difference level and the x-axis a B-Y colour-difference level. The white balance level is varied depending on the standard (to be called "illumination" below) for illuminating an object, and the illumination heads towards red as temperature drops and blue as temperature rises. Further, if it is assumed that the standard of pure white lies at the zero point where the y and x-axes intersect each other, low colour temperature illumination exists within the second quadrant, and high colour temperature illumination exists within the fourth quadrant.

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For example, in the case where a fluorescent lamp, the sun and a halogen lamp are used for illuminating one object, the colour temperatures lie at the points K1, K2, K3, respectively. In order to make the respective illuminations white, the colour temperature is set to the "0" state. Further, when the respective colour temperature points are connected to one another, the colour temperature track in the form of a curve is obtained.

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In this connection, in order to select an extent covering the above colour temperature track, if a range a,-a of the R-Y colour-difference signals is arbitrarily decided on the y-axis, and if a range b,-b of the B-Y colour-difference signals is also arbitrarily decided on the x-axis, the white detecting region is obtained as shown by a shaded area. The absolute value of the R-Y colour-difference signals must be smaller than or equal to that of an arbitrarily set constant ($|R-Y| \leq a \dots (A)$: where a is a positive integer), and the

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absolute value of the B-Y colour-difference signals must be smaller than or equal to that of an arbitrarily set constant ($|B-Y| \leq b...(B)$: where b is a positive integer).

5 Therefore, if it is assumed that the sum of the two positive integers a and b is c, then the equation ($|R-Y| + |B-Y| \leq c...(C)$) has to be satisfied, in which the sum of the absolute value of the R-Y colour-difference signals and that of the B-Y colour-difference signals must be smaller than or equal to an arbitrarily set value c, a positive integer.

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 Meanwhile, for signals satisfying the formulae (A), (B) and (C), when the illuminance is too low, luminance signals Y must satisfy the following conditions in order to sense the white distinctly. As shown in Figure 2, the signal has to be within the range between the uppermost and lowermost levels
15 ($Y \text{ GATE MIN} \leq Y \leq Y \text{ GATE MAX}...(D)$). Further, the maximum level ($Y \text{ GATE MAX}$) must be set larger than 100 percent white and equal to or smaller than the set level of an internal white clip of the camera ($100\% \text{ white} < Y \text{ GATE MAX} \leq Y \text{ WHITE CLIP}...(E)$). Meanwhile, the minimum level ($Y \text{ GATE MIN}$) of the luminance signals ranges between 0 percent level
20 and 100 percent level. ($0\% \text{ LEVEL} \leq Y \text{ GATE MIN} \leq 100\% \text{ WHITE}...(F)$).

 Now, examples of operation of the above described examples of the present invention will be described based on the assumption that formulae (A)
25 to (F) are programmed in the MICOM 9 and set as reference data in the comparing part 8.

 The R, G, B signals which are picked up by the video camera and separated into digital signals are applied to the multipliers 1, 2, 3 to be

multiplied according to the multiplying coefficients and applied to the colour-difference matrix 4.

5 In the embodiment of Figure 3, the multiplier 2 to which the G signals are applied has a fixed multiplying coefficient. The multipliers 1, 3 to which the R, B signals are applied have variable multiplying coefficients according to the data applied to the MICOM 9. Therefore, the white balance can be adjusted by varying the multiplying coefficients of the multipliers 1, 3.

10 Meanwhile, the outputs from the multipliers 1, 2, 3 are applied to the colour-difference matrix 4, and the colour-difference matrix 4 outputs the R-Y and B-Y colour-difference signals to the encoder 5. The encoder 5 receives the Y signals to encode and output the final Y signals and C signals, so as to express particular colours as they are.

15 The output R-Y and B-Y colour-difference signals from the colour-difference matrix 4 and the input luminance signals Y are applied to the sampling part 6 to be read by the appropriate sampling frequency fSPL and subjected to integration in order to sum up the sampled data. Then, they are
20 stored into the relevant address of the memory and transmitted to the comparing part 8 at the same time.

Meanwhile, the comparing part 8 receives the output data from the integrating memory part 7 to decide whether the divided data is included
25 within the luminance signal reference levels and the detecting regions of Figures 1 and 2 according to the formulae (A) - (F). The decision signals are applied to the MICOM 9 to designate an address within the integrating memory part 7 by a MICOM rule applied thereon, so that the integrating

memory part 7 applies the integrated data of the R-Y and B-Y colour-difference signals to the MICOM 9.

5 Accordingly, the MICOM 9 compares the output R-Y integrated data with the B-Y integrated data from the integrating memory part 7. In order to achieve the white balance, the MICOM 9 outputs the multiplying coefficients to the multipliers 1, 3 to satisfy the formulae $|R-Y| = 0...(G)$ and $|B-Y| = 0...(H)$.

10 In the circuit operating as described above, the R, G, B signals are applied through the multipliers 1, 2, 3 to the colour-difference matrix 4, and the R-Y and B-Y colour-difference signals are applied to the encoder 5. Then, the signals are sampled by the sampling part 6 at the appropriate sampling frequency fSPL and integrated by the integrating memory part 7 to
15 be recorded into the respective addresses of the memory corresponding to the division of the picture. The comparing part 8 decides whether the integrated and divided data is included in the regions of Figures 1 and 2, and respective decision signals are applied to the MICOM 9. The MICOM 9 designates the proper addresses so that the integrated R-Y and B-Y data can be applied and
20 also the multiplying coefficients of the multipliers 1, 3 can be adjusted to satisfy the formulae $R-Y = 0$ and $B-Y = 0$. By repeating these operations, automatic adjustment of the white balance is achieved to process the digital signals in the video camera.

25 In the embodiment of Figure 4 the comparing part 8 is arranged differently. In Figure 3 the comparing part 8 operates in such a manner that the white balance is adjusted by the multipliers 1, 2, 3, the output R-Y and B-Y colour-difference signals from the colour-difference matrix 4 are sampled in the sampling part 6, and the integrated and divided output data from the

integrating memory part 7 are compared in the comparing part 8. On the other hand, according to Figure 4, the R, B signals are mixed with the Y signal and amplified by the B-Y' generating part 11 and the R-Y' generating part 12 before being colour-separated and before being subjected to the white balance adjustments. Thus, the R-Y' signals and the B-Y' signals and the Y signals are compared with one another and evaluated. Thus, the switching part 10 is controlled when they are in the regions of Figures 1 and 2, satisfying the formulae (A) - (F), so that the R-Y and B-Y colour-difference signals sampled in the sampling part 6 according to the sampling frequency fSPL are selectively applied to the integrating memory part 7, to be stored into the memory corresponding to the picture division. The MICOM 9 designates the addresses in the integrating memory part 7 and receives the integrated R-Y and B-Y data to compute, compare, and evaluate. Then, the MICOM 9 outputs the multiplying coefficients of the multipliers 1, 3 to satisfy formulae (G) and (H) for completing the adjustment of the white balance.

In Figure 3, the signals are input after the white balance adjustment according to the compare-decided signals of the comparing part 8. In Figure 4, the R-Y' and B-Y' signals are applied before the white balance adjustment so that the white detecting region of the colour temperature track remains equal regardless of the value of the multiplying coefficient from the MICOM 9 and the comparing signal level is kept constant without variation. Consequently, the comparison can be carried out stably.

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Referring to Figure 5, the output Y signal and the R-Y and B-Y colour-difference signals from the colour-difference matrix 4 from the sampling of the colour-difference signals to the inputting into the MICOM 9 are applied to both the encoder 5 and the sampling part 6 to be sampled at the appropriate

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sampling frequency fSPL. Then, the signals are temporarily stored into the latching parts 16, 17 and applied to the comparing part 8.

Therefore, if it is found that the formulae (A) - (F) are satisfied by the sampled input data from the sampling part 6, the comparing part 8 activates the latching parts 16, 17 to be integrated and the integrated data is stored into the memory groups 18, 19 corresponding to the division of the picture.

Here, two memory groups 18, 19 are required, one for R-Y data and another one for B-Y data and each of the memory groups 18, 19 has a number n of picture-divided storing locations.

The data stored in the memory groups 18, 19 are read by the address stored by the MICOM 9 and applied to the MICOM 9. The MICOM 9 carries out comparisons, evaluations and computations on the data to output the multiplying coefficients for satisfying the formulae (G) and (H). The multiplying coefficients from the MICOM 9 are applied through the internal bus 20 to multiplying coefficient registers 13, 15 of the multipliers 1 and 3 for adjusting the white balance.

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Here, the addresses in the memory groups 18, 19 are designated by the programs stored in the MICOM 9. For example, the upper portion of a picture often contains usually the sky or some background scene, and therefore, the address is designated based on a certain rule that a certain amount is shielded in order to prevent errors on the white balance. Further, the picture might be divided and a certain weighted value is assigned, or the "fuzzy rule" might be applied.

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Meanwhile, Figure 6 is an alternative embodiment of a portion of the circuit of Figure 5, corresponding to the portion from the sampling of the R-Y and B-Y signals and the Y signal to their input to the MICOM 9. The R-Y and B-Y signals are sampled by the sampling part 6 based on the sampling frequency f_{SPL} , and the sampled data is integrated by the respective integrators 21, 22, 23 to be applied to n picture-divided memories 24, 25, 26.

The data stored in the memories 24, 25, 26 is read in accordance with the rule-applied address designation by the MICOM 9. The data is applied to the comparing and integrating part 27, and the R-Y and B-Y data included in the regions of Figures 1 and 2 and satisfying the formulae (A) - (F) are integrated and applied to the MICOM 9.

Then, the MICOM 9 carries out comparisons, evaluations, and computations on the output R-Y and B-Y data from the comparing and integrating part 27 to output the multiplying coefficients to satisfy the formulae (G) and (H) through the internal bus 20, for adjusting the white balance.

Thus, the illustrated examples of automatic white-balancing circuits embodying the present invention comprise sampling means to receive the separated R, G, B signals for sampling the Y signals and the R-Y and B-Y colour-difference signals of the colour-difference matrix at the proper sampling frequency, integrating memory means for integrating the data sampled by the sampling means and summing up and storing the data corresponding to the picture. comparing means for deciding whether the integrated data of the integrating memory means is included in the white balance adjusting regions, and means receiving the output data from the comparing means for designating the address in the integrating memory means

by the MICOM and carrying out integrating and computing on the integrated data to output a multiplying coefficient to the multiplier, thereby carrying out the adjustment of the white balance.

- 5 Thus, there is provided an automatic white-balancing circuit for a video camera for processing digital signals. Therefore, the white balance of a digital video camera can be automatically adjusted, thereby enabling completely digitalizing of a video camera.



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CLAIMS

1. An automatic digital white-balancing circuit comprising:

5 means for receiving colour-separated digital signals;

means for receiving and carrying out an evaluation of colour-difference signals generated from said colour-separated digital signals and a luminance digital signal; and

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means for adjusting the gain of at least some of said colour-separated digital signals in response to said evaluation, to obtain a desired white balance.

15 2. An automatic digital white-balancing circuit as claimed in Claim 1, further comprising:

multipliers for multiplying colour-separated digital signals based on multiplying coefficients:

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a colour-difference matrix for matrixing the outputs of said multipliers to output R-Y and B-Y colour-difference signals;

25 an encoder for encoding a Y signal and said output R-Y and B-Y colour-difference signals from said colour-difference matrix;

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sampling means for sampling said Y signal and said R-Y and B-Y colour-difference signals from said colour-difference matrix at a sampling frequency fSPL;



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integrating memory means for integrating the data sampled from said sampling means and storing said data into respective addresses corresponding to picture division;

5 comparing means for deciding whether integrated data is included in a white balance adjusting region; and

 a microcomputer for receiving decision signals from said comparing means for designating addresses in said integrating memory means and to
10 receive said integrated colour-difference signals for applying multiplying coefficients to said multipliers in order to adjust the white balance.

3. An automatic digital white-balancing circuit as claimed in claim 1, further comprising:

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 B-Y' generating means and R-Y' generating means for mixing and amplifying the colour-separated digital R,B signals and said Y signal to generate B-Y' and R-Y' signals and apply them to said comparing means; and

20 switching means for being driven by the output decision signals from said comparing means based upon the input R-Y', B-Y' and Y' signals to apply said sampled data from said sampling means to said integrating memory means.

25 4. An automatic digital white-balancing circuit as claimed in claim 1, further comprising:

 latching means for integrating and temporarily storing said sampled data from said sampling means;

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memory groups for storing said sampled data into picture-divided memories by controlling the driving of said latching means according to the output from said comparing means based upon the sampled data values R-Y, B-Y and Y; and

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registers for storing the addresses of said memory groups and evaluating the read data to apply said multiplying coefficients from said microcomputer through an internal bus to said multipliers.

- 10 5. An automatic digital white-balancing circuit as claimed in claim 4, further comprising:

integrators for integrating said sampled output data from said sampling means;

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memories for storing the integrated data of said integrators corresponding to n divisions of a picture; and

20 comparing and integrating means for reading out the stored data of said memories at addresses supplied from said microcomputer and carrying out integration and comparison of said read data to apply the data to said microcomputer.

- 25 6. An automatic digital white-balancing circuit substantially as hereinbefore described with reference to Figure 3, 4, 5 or 6 of the accompanying drawings.



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7. An automatic digital white-balancing circuit substantially as hereinbefore described with reference to Figures 1 and 2, together with Figure 3, 4, 5 or 6 of the accompanying drawings.
- 5 8. A video camera provided with an automatic digital white-balancing circuit according to any of the preceding claims.
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