

CIRCUIT FOR DETECTING BACK LIGHT

5 This invention concerns a circuit for detecting back light, e.g. for use in a camera.

 According to the present invention there is provided a circuit for detecting back light comprising: switching circuits for selectively connecting a
10 reference resistive device, a first photo-conductive device arranged to respond to the brightness of a portion of an object to be photographed surrounding a central portion thereof, and a second photo-conductive device arranged to respond to the brightness of the said
15 central portion of the object, to a time constant circuit, to determine the time constant; a pulse generating circuit that receives the output from the time constant circuit and produces pulses the number of which corresponds to the resistance value of the
20 respective one of said devices which has been connected by one of the switching circuits; a counter circuit for counting the number of pulses delivered from the pulse generating circuit; and an arithmetic circuit for comparing the magnitude of the ratio of the total count obtained by the counter circuit when the first photo-
25 conductive device is connected to the total count obtained when the reference resistive device is connected, with the magnitude of the ratio of the total count obtained when the second photo-conductive device
30 is connected to the total count obtained when the

reference resistive device is connected.

There may be means for compensating for differences in the resistances of the first and second photo-conductive devices when they receive light of the same brightness.

The first and second photo-conductive devices may be mounted in a common cell.

The time constant circuit may be arranged to produce an oscillation frequency which is functionally related to the resistive value of the respective device to which it is selectively connected. Thus, the time constant circuit may comprise an oscillator inverters and a capacitor, the said oscillation frequency depending upon the said resistive value and the capacitance of the capacitor.

The invention also comprises a camera provided with a circuit as set forth above.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figure 1 is a circuit diagram of a first embodiment of a circuit according to the present invention;

Figure 2 is a time chart for illustrating the operation of the circuit shown in Figure 1;

Figure 3 is a front elevation of one embodiment of a photo-conductive device which may be used in the circuit shown in Figure 1;

Figure 4 is a circuit diagram of a second embodiment of a circuit according to the present invention;

Figure 5 is a time chart for illustrating the operation of the circuit shown in Figure 4;

Figure 6 is a circuit diagram of a third embodiment of a circuit according to the present

invention;

Figure 7 is a time chart for illustrating the operation of the circuit shown in Figure 6; and

Figure 8 is a circuit diagram of a prior back
5 light detecting circuit.

A prior circuit known to the Applicants for detecting back light is shown in Figure 8. The circuit comprises photo-diodes 29 and 30 both of which consist of silicon. The photo-diode 29 responds to the
10 brightness of the central portion of the object to be photographed, the term "object" being used herein in a wide sense to include an area. The photo-diode 30 responds to the brightness of a portion of the object surrounding a central portion thereof. Their output
15 currents, which are proportional to the brightness, are supplied to current to voltage converter circuits 31 and 32 to convert the currents into voltages. A pulse generating circuit 33 produces pulses of a pulse duration corresponding to its input voltage. First,
20 the output from the converter circuit 31 is selected by a switching circuit 34 and fed to the pulse generating circuit 33. That is, a current corresponding to the brightness of the central portion of the object is converted into a voltage and supplied to the pulse
25 generating circuit 33. When a trigger signal arrives at a terminal P of the pulse generating circuit 33, the pulse generating circuit 33 generates pulses having a pulse duration proportional to the brightness. The pulse duration is measured by a counter circuit (not
30 shown) or the like. The measured value is regarded as indicating the brightness of the central portion of the object.

Then, the converter circuit 32 is selected by the switching circuit 34. The output current from the

photo-diode 30 is converted into a pulse duration in the same manner as the foregoing. Thus, the brightness of the surrounding portion of the object is recognised.

5 The pulse duration proportional to the brightness is calculated by an arithmetic circuit (not shown). If it is determined that the central portion of the object is darker than the surrounding portion or that the brightness is below a certain level, then back light is judged to be detected. Then, a strobe is flashed to
10 prevent the central portion from being dark.

The circuit shown in Figure 8, however, uses relatively expensive photo-diodes of silicon. Since the output currents from the photo-diodes are very weak, amplifier circuits or the like handling the weak
15 currents are needed. Also, a dedicated photometric IC independent of a central processing unit CPU is necessitated. This also increases the cost.

Because very weak currents are treated, extraneous noise tends to cause malfunction, and it is impossible
20 to make the distance between each photo-diode and the photometric IC large.

Further, as two current to voltage converter circuits 31, 32 are employed, their characteristics must be made substantially the same since otherwise
25 adequate photometric accuracy would not be obtained. However, it is difficult to completely suppress variations of constants among the parts of these circuits, and variations in the characteristics due to temperature changes. For these reasons, it has been
30 unavoidable that the photometric accuracy is adversely affected.

The object of the present invention, therefore, is to provide a simplified circuit having improved photometric accuracy.

Referring, therefore, to Figure 1, a first photo-conductive device 1 responds to the brightness of a portion of an object to be photographed surrounding the central portion thereof. A second photo-conductive device 2 responds to the brightness of the central portion of the object. In the present example, these devices are made from CdS and are equal in the area of their light sensitive surface. Indicated by numeral 3 is a reference resistive device. In this example, the resistive device 3 consists of a variable resistor. A time constant circuit 4 constitutes a one shot multi-vibrator, and comprises a gate circuit 5, a capacitor 6, and an inverter 7. The combination of the capacitor 6 and any one of the photo-conductive devices 1, 2 and the reference resistive device 3 determines the time constant. Switching circuits 8 to 10 selectively connect the photo-conductive devices 1, 2, and the reference resistive device 3 to the time constant circuit 4 to determine the time constant. A gate circuit 11 forms a pulse generating circuit and has an input terminal CL to which clock pulses are supplied. Counter circuits 12A to 12C count the number of pulses delivered from the pulse generating circuit 11. An arithmetic circuit 13 performs arithmetic operations as described below.

In operation, immediately before the production of a signal T (Figure 2) that triggers the time constant circuit 4, a pulse S_A (Figure 2) is generated to turn on a switching circuit S_A (Figure 1). Then, the reference resistive device 3 is connected to the time constant circuit 4. Subsequently, the triggering signal T is produced to cause the inverter 7 to produce pulses Q (Figure 2) having a pulse duration T_s that is determined by the resistance value R_{vr} of the reference

resistive device 3 and the capacitance of the capacitor 6. When these pulses are being produced, the pulse generating circuit 11 produces clock pulses which are supplied to the counter circuit 12A and counted.

5 The pulse duration T_s is given by the expression

$$R_{vr} \cdot C \cdot \ln (V_e - V_{th}) / V_e$$

where C is the capacitance of the capacitor 6, V_e is the source voltage and V_{th} is the threshold voltage of the inverter 7. Therefore, the duration is proportional to the resistance R_{vr} of the reference resistive device 3.

Then, a pulse S_B (Figure 2) turns on the switching circuit 9, connecting the first photo-conductive device 1 to the time constant circuit 4. Thereafter, a triggering signal is produced. At the same time, the inverter 7 produces a pulse Q (Figure 2) having a pulse duration T_{av} corresponding to the brightness of the surrounding portion of the object to be photographed. While this pulse persists, clock pulses are fed to the counter circuit 12B, and the number is counted. The pulse duration T_{av} is given by

$$R_{av} \cdot C \cdot \ln (V_e - V_{th}) / V_e$$

where R_{av} is the resistance of the first photo-conductive device 1.

25 Then, a pulse S_C (Figure 2) turns on the switching circuit 10 to thereby connect the second photo-conductive device 2 to the time constant circuit 4, after which a triggering signal is generated. At this time, a pulse Q (Figure 2) of a pulse duration T_{sp} corresponding to the brightness of the central portion of the object is produced. While this pulse persists, clock pulses are furnished to the counter circuit 12C, and the number of the pulses is counted. The pulse duration T_{sp} is given by

$$R_{sp} \cdot C \cdot \ln(V_e - V_{th}) / V_e$$

where R_{sp} is the resistance of the second photo-conductive device 2.

The arithmetic circuit 13 performs arithmetic operations in the manner described now. First, the ratio of the pulse duration T_{av} which is obtained when the first photo-conductive device 1 is connected, to the pulse duration T_s obtained when the reference resistive device 3 is connected, is calculated to find the brightness of the surrounding portion of the object. This ratio T_{av}/T_s is equal to the ratio of the resistance R_{av} of the first photo-conductive device 1 to the resistance R_{vr} of the reference resistive device 3, i.e. R_{av}/R_{vr} .

Then, the ratio of the pulse duration T_{sp} which is derived when the second photo-conductive device 2 is connected, to the pulse duration T_s obtained when the reference resistive device 3 is connected, is calculated to find the brightness of the central portion of the object. This ratio T_{sp}/T_s equals the ratio R_{sp}/R_{vr} , i.e. the ratio of the resistance R_{sp} of the second photo-conductive device 2 to the resistance R_{vr} of the reference resistive device 3.

Since the capacitance of the capacitor 6, the power voltage V_e and the threshold voltage V_{th} are cancelled out, the aforementioned ratios depend only on the resistance values of the reference resistive device 3 and the first photo-conductive device 1. Consequently, the ratios are affected by none of the variations of the power voltage, the threshold voltage changing in response to the power voltage, capacitance variations due to the ageing of the capacitor and temperature variations, and other changes.

The ratio T_{av}/T_s representing the brightness of

the surrounding portion of the object is compared in magnitude with the ratio T_{sp}/T_s expressing the brightness of the centre to determine whether the light is back light. According to the result, a strobe is
 5 caused to emit light, or some other operation is performed.

The resistance value of the reference resistive device 3 is so adjusted that it equals the resistance value of each of the photo-conductive devices 1, 2 at an
 10 appropriate brightness.

In the above example, the light incident surface of the photo-conductive devices 1 and 2 are equal in area. It has been assumed that if they receive light of the same brightness, they show the same value of
 15 resistance. It is also possible, however, that the two light incidence surfaces differ in area. In this case, the period of the clock pulses is switched to some other value according to the ratio of one area to the other area. In particular, when the pulse durations T_s and
 20 T_{av} are counted, the first reference clock pulses are used. When the pulse duration T_{sp} is counted, the second clock pulses are employed. If the ratio of the resistance of the first photo-conductive device 1 to the resistance of the second photo-conductive device 2 is
 25 1:4, for example, the ratio of the period of the first clock pulses to the period of the second clock pulses is set to 1:4.

The photo-conductive devices 1 and 2 may be constructed as shown in Figure 3. The first photo-
 30 conductive device 1 consists of CdS and responds to the brightness of the central portion of an object to be photographed. The device 1 is formed in the centre of a cell. The second photo-conductive device 2, which also consists of CdS, responds to the brightness of the

surrounding portion of the object. The device 2 is formed in the portion of the cell surrounding the device 1. Electrodes 14 to 16 are provided of which the electrode 15 is a common electrode.

5 In this example, the two CdS devices are formed in one cell in one manufacturing step and, therefore, their γ characteristics, which determine the relationship between the amount of light and the resistance value, can be made substantially equal.

10 The present invention, however, is not limited to the arrangement shown in Figure 3. It is also possible to form CdS devices in separate cells.

15 There is now described an embodiment of the present invention in which the brightness of an object to be photographed is converted into an oscillation frequency to detect back light.

Referring to Figure 4, a time constant circuit 17 constitutes a CR oscillator, and comprises inverters 18, 19 and a capacitor 20. A reference resistive device 3 and photo-conductive devices 1 and 2 are selectively connected by switching circuits 8, 9, 10 to the circuit 17 to determine the time constant. A one shot multi-vibrator 21 produces pulses of a given duration. A pulse generating circuit 22 consists of a gate circuit whose output is supplied to a counter circuit (not shown) similar to the counter circuit 12A, 12B, 12C shown in Figure 1.

It is to be noted that like components are denoted by like references numerals in both Figures 1 and 4.

30 In operation, three triggering pulses T (Figure 5) are supplied to the input terminal T (Figure 4) of the one shot multi-vibrator 21. This multi-vibrator delivers pulses Q (Figure 5) of a given duration T.

The switching circuits 8, 9, 10 are successively

turned on by pulses S_A , S_B , S_C respectively which are shown in Figure 5. When the switching circuit 8 is turned on, the reference resistive device 3 is connected to the time constant circuit 17, thus enabling oscillation. The oscillation frequency is determined by the reference resistive device 3 and the capacitance of the capacitor 20. While the one shot multi-vibrator 21 is producing pulses during periods T , the generated output is allowed to pass through the pulse generating circuit 22. The number of pulses P_s is counted.

The switching circuit 9 is then turned on to connect the first photo-conductive device 1 with the time constant circuit 17. The circuit generates a frequency which is determined by the resistive value and the capacitance of the capacitor 20. The generated output passes through the pulse generating circuit 22 during periods T in the same manner as the foregoing. The number of pulses P_{av} is counted.

Subsequently, the switching circuit 10 is turned on to connect the second photo-conductive device 2 to the time constant circuit 17, which then generates signals. The oscillation frequency is determined by the resistance value and the capacitance of the capacitor 20. The generated output passes through the pulse generating circuit 22 during periods T in the same way as the foregoing. The number of pulses P_{sp} is counted.

The ratios of the pulse numbers P_{av}/P_s and P_{sp}/P_s are then calculated. These two ratios are compared in magnitude to detect back light.

The relationship of the compared ratios P_{av}/P_s and P_{sp}/P_s to the brightness is now described. Assuming that the capacitance of the capacitor 20 is constant,

the oscillation frequency f of the time constant circuit 17 is given by

$$f = 1 / KR$$

where K is a constant, and R is the resistance value 5 selected by the switching circuits 8 to 10.

The relationship of the resistance values R_{av} , R_{sp} of the photo-conductive devices 1 and 2 to the brightness of the object to be examined are given by the expressions

$$\begin{aligned} R_{av} &= R_0 \cdot 2^{\gamma n} \\ R_{sp} &= R_0 \cdot 2^{\gamma n} \end{aligned}$$

where n is the brightness index, γ is a constant determined by the γ characteristics of the photo-conductive device 1 or 2, and R_0 is the resistance 15 value of the photo-conductive device 1 or 2 at a certain brightness at which $n = 0$.

The relationship of the number of pulses P passing through the pulse generating circuit 22 to the oscillation frequency f is given by

$$20 \quad P = T f = T / KR$$

where T is the pulse duration of the output from the one shot multi-vibrator 21.

The value of the reference resistive device 3 is so set that the resistance R_s of the reference resistive 25 device 3 and the resistances R_{av} , R_{sp} of the photo-conductive devices 1, 2 satisfy the relationship

$$R_s = R_{av} = R_{sp}$$

at a certain brightness. Under this condition, the ratios P_{av}/P_s and P_{sp}/P_s are given by

$$\begin{aligned} 30 \quad P_{av}/P_s &= P_{sp}/P_s \\ &= (T/K \cdot R_0 \cdot 2^{\gamma n}) / (T/K \cdot R_s) = 1/2^{\gamma n} \end{aligned}$$

Therefore, if the γ characteristics of the photo-conductive devices 1 and 2 are known, then the brightness indices of the surrounding portion and the

central portion of the object can be calculated from the ratios P_{av}/P_s and P_{sp}/P_s . If the relationship

$$P_{av}/P_s > P_{sp}/P_s$$

holds, then it follows that the brightness of the
 5 surrounding portion of the object is higher than the central portion, indicating back light.

In the embodiment of Figure 4, the capacitor 20 can have a small capacitance, for example of the order of 50 pF. This permits the device to be fabricated in
 10 the form of an integrated circuit. Where it is not built as an integrated circuit, inexpensive devices can be used.

Figure 6 shows a further embodiment. In this Figure, a capacitor 23 constitutes a time constant
 15 circuit 24. A switching circuit 25 discharges the capacitor 23. A reference voltage V_{ref} is applied to one input of a comparator 26. Indicated by numeral 27 is an inverter. A pulse generating circuit 28 consists of a gate circuit whose output is supplied to a counter
 20 circuit similar to the counter circuit shown in Figure 1.

It is to be noted that like components are denoted by like reference numerals in both Figures 1 and 6.

In operation, pulses S_A to S_C (Figure 7) are
 25 successively supplied to the switching circuits 8 to 10 respectively. When none of these pulses are produced, signal "1" is applied to terminal S_D as shown in Figure 7. Normally, the switching circuit 25 operates to discharge the capacitor 23.

30 Supply of the pulse S_A (Figure 7) turns on the switching circuit 8. Simultaneously, the switching circuit 25 is turned off. Thus, the capacitor 23 is recharged with a time constant determined by the capacitance of the capacitor 23 and the resistance of

the reference resistive device 3. The comparator 26 produces a pulse of level 0 having a pulse duration equal to the time T_s taken for the voltage across the capacitor to reach the reference voltage V_{ref} . While this pulse persists, the pulse generating circuit 28 generates clock pulses A (Figure 7). The clock pulses are supplied to the counter circuit. The pulse duration T_s is measured.

When the pulse from the terminal S_A ceases, the switching circuit 25 is turned on to discharge the capacitor 23.

When the switching circuit 9 is turned on, the capacitor 23 is re-charged with a time constant determined by the first photo-conductive device 1 and the capacitor 23. Then, the comparator 26 produces a pulse having a pulse duration T_{av} corresponding to the brightness of the surrounding portion of the object. While this pulse persists, the pulse generating circuit 28 produces clock pulses, and the pulse duration T_{av} is measured.

Then, the switching circuit 25 is turned on in the same manner as the foregoing. After the capacitor 23 is discharged, the switching circuit 10 is turned on. This re-charges the capacitor 23 with a time constant determined by the photo-conductive device 2 and the capacitor 23. Then, the comparator 26 produces a pulse T_{sp} having a pulse duration T_{sp} corresponding to the brightness of the central portion of the object. While this pulse persists, the pulse generating circuit 28 generates clock pulses and the pulse duration T_{sp} is measured.

The ratios T_{av}/T_s and T_{sp}/T_s are calculated from the results of the measurements. These two ratios are compared in magnitude to detect back light.

In the embodiments described above, the effects of constants of circuit elements, variations of the power voltage due to ageing and temperature variations can be eliminated. This allows back light to be

5 detected with improved accuracy. Therefore, inexpensive CdS photo-conductive devices can be used. Also, amplifier circuits which treat quite weak electric currents can be dispensed with.

The circuit of the present invention can be
10 incorporated in a logic IC such as a micro-computer. Consequently, the circuit configuration is made simple. Hence, a reduction in the cost can be achieved.

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C L A I M S

1. A circuit for detecting back light comprising:
switching circuits for selectively connecting a
5 reference resistive device, a first photo-conductive
device arranged to respond to the brightness of a
portion of an object to be photographed surrounding a
central portion thereof, and a second photo-conductive
device arranged to respond to the brightness of the said
10 central portion of the object, to a time constant
circuit, to determine the time constant; a pulse
generating circuit that receives the output from the
time constant circuit and produces pulses the number of
which corresponds to the resistance value of the
15 respective one of said devices which has been connected
by one of the switching circuits; a counter circuit for
counting the number of pulses delivered from the pulse
generating circuit; and an arithmetic circuit for
comparing the magnitude of the ratio of the total count
20 obtained by the counter circuit when the first photo-
conductive device is connected to the total count
obtained when the reference resistive device is
connected, with the magnitude of the ratio of the total
count obtained when the second photo-conductive device
25 is connected to the total count obtained when the
reference resistive device is connected.
2. A circuit as claimed in claim 1, in which there
are means for compensating for differences in the
resistances of the first and second photo-conductive
30 devices when they receive light of the same brightness.
3. A circuit as claimed in claim 1 or 2, in which the
first and second photo-conductive devices are mounted in
a common cell.
4. A circuit as claimed in any preceding claim, in



which the time constant circuit is arranged to produce an oscillation frequency which is functionally related to the resistive value of the respective device to which it is selectively connected.

5. A circuit as claimed in claim 4, in which the time constant circuit comprises an oscillator, including inverters and a capacitor, the said oscillation frequency depending upon the said resistive value and the capacitance of the capacitor.

6. A circuit for detecting back light substantially as hereinbefore described with reference to and as shown in Figures 1 and 2; Figures 4 and 5; or Figures 6 and 7 of the accompanying drawings.

7. A camera provided with a circuit as claimed in any preceding claim.
