

PHOTOMETRIC CIRCUIT

The present invention relates to photometric circuits for cameras or the like.

5 With the increase in popularity of automatic cameras, it has become desirable to convert information related to the luminance of a scene or object to be photographed into a digital signal. To this end, there has been proposed a digital photometric circuit as shown
10 in Figure 4 arranged such that a photo-conductive element R_t for detecting luminance of a scene to be photographed and a capacitor C are connected in series and the number of clock pulses generated during the period from the time when photometric measurement is
15 initiated until the time when the terminal voltage of the capacitor C reaches a reference voltage is counted. Such a digital photometric circuit is disclosed, for example, in Japanese Laid Open Patent Specification No. 60-164728 (1985).

20 The above described digital photometric circuit requires the capacitor C to have a large capacitance, e.g. about $0.22 \mu\text{F}$, and therefore suffers from the disadvantage that it is difficult to fabricate the photometric circuit in the form of an integrated circuit and
25 the cost of a capacitor C is relatively high. There is also the disadvantage that the measuring accuracy may be reduced due to fluctuations in the electro-static capacitance of the capacitor C or fluctuations in the reference voltage.

30 Furthermore, as the luminance of the scene or object to be photographed becomes greater, the capacitor is charged more quickly and hence the measuring accuracy is reduced. Since the degree of accuracy, when the luminance is relatively high, is

relatively low due to the mechanical structure of the camera, the accuracy is synergistically lowered.

The known digital photometric circuit also suffers from the disadvantage that a comparator, which is used to make a comparison with the reference voltage, needs a power supply which is capable of supplying a relatively high voltage, for example, three times the threshold voltage of each of three transistors, T_1 , T_2 and T_3 , because these transistors are interposed in series with respect to a power supply V_e , as shown in Figure 4.

The present invention seeks to provide a photometric circuit in which it is possible to reduce the required capacitance of a capacitor, lower the voltage required to drive the circuitry and yet achieve high measuring accuracy.

According to the present invention there is provided a photometric circuit comprising: an oscillation circuit having a resistor and a capacitor as frequency determining elements; a photo-conductive element which, in operation, responds to the luminance of an object of measurement; a switching circuit for causing said photo-conductive element to be selectively operatively connected in said oscillation circuit so that said photo-conductive element functions as a frequency determining element; and a frequency ratio calculating circuit for calculating the ratio of the oscillation frequency obtained when said photo-conductive element is operatively connected in said

oscillation circuit, so as to function as a frequency determining element to the oscillation frequency obtained when said photo-conductive element is not operatively connected in said oscillation circuit.

5 In one embodiment the switching circuit is arranged so that the resistor is operatively connected in the oscillation circuit when the photo-conductive element is not operatively connected in the oscillation circuit.

10 In another embodiment the switching circuit comprises a first switch for short circuiting the photo-conductive element so that the resistor is operatively connected with the oscillation circuit and a second switch for short circuiting the resistor so that the
15 photo-conductive element is operatively connected with the oscillation circuit.

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

Figure 1 is a circuit diagram of one embodiment of
20 a photometric circuit according to the present invention;

Figure 2 is a time chart illustrating the operation of the photometric circuit of Figure 1;

Figure 3 is a circuit diagram of an alternative form of oscillation circuit for the photometric circuit
25 of Figure 1;

Figure 4 is a circuit diagram of a conventional photometric circuit; and

Figure 5 is a block diagram of a frequency ratio calculating circuit of a photometric circuit according
30 to the present invention.

Referring to Figure 1, there is illustrated a photometric circuit according to the present invention. An oscillation circuit 1 includes a resistor 3 and a capacitor 5 as frequency determining elements. The

oscillation circuit 1 also comprises a photo-conductive element 2 such as a CdS element which responds to the luminance of an object of measurement, for example, a scene or object to be photographed, a switching circuit 4 and inverters 6, 7. A one shot pulse generating circuit 8 generates a pulse with a predetermined width. Reference numeral 9 denotes a gate circuit. A frequency ratio calculating circuit 10 comprises a plurality of counters or the like to calculate a ratio of the oscillation frequency obtained when the photo-conductive element 2 is operatively connected in the oscillation circuit 1 to the oscillation frequency obtained when the resistor 3 is operatively connected in the oscillation circuit 1. A data memory circuit 11 stores exposure values corresponding to the frequency ratios with the output from the frequency ratio calculating circuit 10 used as an address. A switching control circuit 12 effects switching of the switching circuit 4.

The operation of the photometric circuit of Figure 1 will next be explained. When a release button (not shown) is pressed to measure the luminance of an object of measurement, two trigger pulse signals are supplied to a terminal P, as shown in Figure 2a. In response to the first trigger pulse signal, the output of the switching control circuit 12 is set to "1", as shown in Figure 2b. In consequence, the switching circuit 4 is switched over to a terminal 4a to select the reference resistor 3. Accordingly, the oscillation circuit 1 oscillates at a reference frequency which is determined by the values of the reference resistor 3 and the capacitor 5 and the oscillation output is supplied to the gate circuit 9.

The first trigger pulse signal also causes the one shot pulse generating circuit 2 to generate and supply a

pulse with a predetermined width T shown in Figure 2c to the gate circuit 9. Whilst this pulse is being generated, the oscillation output of the oscillation circuit 1 is passed, as shown in Figure 2d, and the number P_r of output pulses is counted in the frequency ratio calculating circuit 10.

When the trigger pulse signal shown in Figure 2a is supplied, the output of the switching control circuit 12 is inverted to "0", as shown in Figure 2b, so that the switching circuit 4 is switched over to a terminal 4b to select the photo-conductive element 2. Accordingly, the oscillation circuit 1 oscillates at a frequency which corresponds to the resistance value of the photo-conductive element 2, that is, the luminance of the object of measurement. During another pulse generated from the one shot pulse generating circuit 8, the oscillation output is supplied to the frequency ratio calculating circuit 10 where the number P_x of output pulses is counted in the same way as above and a frequency ratio P_x/P_r is calculated.

On the basis of the result of the calculation, an exposure value corresponding to the luminance of the object of measurement is read out from the data memory circuit 11.

The relationship between the ratio P_x/P_r and the luminance of the object of measurement will next be explained. If the capacitance C of the capacitor 5 is fixed, the oscillation frequency f of the oscillation circuit 1 is expressed by the resistance value R selected by the switching circuit 4 as follows:

$$f = 1/KR \quad (K \text{ is a constant}).$$

The relationship between the luminance of the object of measurement and the resistance value R_x of the photo-conductive element 2 is expressed as follows:

$$R_x = R_0 2^{\gamma n}$$

where

n : the index of luminance

γ : a constant determined by the characteristics of the photo-conductive element 2

R_0 : the resistance value of the photo-conductive element 2 at a specific luminance (i.e. when $n = 0$).

If the width of the pulse output from the one shot pulse generating circuit 8 is represented by T , the relationship between the oscillation frequency f and the number P of pulses passing through the gate circuit 9 is expressed as follows:

$$P = Tf = T/KR \quad \dots(1)$$

Accordingly, if the reference resistor 3 is set so that the relationship between the resistance R_r of the reference resistor 3 and the resistance value R_x of the photo-conductive element 2 at a specific luminance is $R_r = R_x = R_0$, the above described ratio P_x/P_r at the luminance n is as follows:

$$\begin{aligned} P_x/P_r &= (T/K.R_0 2^{\gamma n}) / (T/K.R_r) \\ &= 1/2^{\gamma n}. \end{aligned}$$

Accordingly, if the value of γ of the photo-conductive element 2 is known in advance, it is possible to obtain the luminance index n from the above described ratio P_x/P_r .

As will be clear from the expression (1), the higher the luminance, the larger the number P_x of pulses, so that the ratio P_x/P_r varies by a large margin in response to a slight change in resistance of the photo-conductive element 2 and it is therefore possible to increase the measuring accuracy when the luminance is relatively high.

Although it is generally known that an oscillation circuit is not stable against temperature and power supply voltage fluctuations and therefore high performance cannot be obtained, the oscillation circuit 5 1 wherein the reference oscillation frequency is measured on each occasion and a ratio with respect to it is calculated, as described above, is independent of fluctuations caused by external factors.

Further, the capacitor 5 is only required to have 10 a small capacitance, for example, about 50 pF, and therefore it is possible to fabricate the photometric circuit in the form of an integrated circuit. Even if it is not formed into an integrated circuit, it is possible to use a capacitor which is less costly.

15 It should be noted that it is also possible to employ in a photometric circuit according to the present invention an oscillation circuit having an arrangement such as that shown in Figure 3. In this case, the oscillation circuit is first oscillated with the 20 reference resistor 3 to be connected when a switching circuit 4 is closed so that the photo-conductive element is short circuited, and then the oscillation circuit is oscillated with the photo-conductive element 2 25 operatively connected when a switching circuit 13 is closed so that the reference resistor 3 is short circuited. It is thus possible with this arrangement to obtain the same functions and effects as those obtained with the photometric circuit of Figure 1.

Figure 5 is a circuit diagram of the frequency 30 ratio calculating circuit of Figure 1. This frequency ratio calculating circuit comprises a pre-settable repeat up counter 21, an up counter 22 which adds 1 as a result of overflow or a carry signal from the counter 21, a register 24 which holds the number P_r , a

register 23 which holds the ratio P_x/P_r , and a control circuit 25 which controls both the counters 21, 22 and the registers 23, 24.

The operation of this frequency ratio calculating circuit is as follows. Initially the control circuit 25 generates a signal which clears the counters 21, 22. When a pulse is generated from the one shot pulse generating circuit 8 by a trigger signal, pulses are supplied to the counter 21 from the oscillation circuit and the counter 21 thus begins to count. When the pulse generated from the one shot pulse generating circuit 8 is terminated, the pulse number P_x remains in the counter 21. The oscillation frequency is controlled to prevent the counter 21 from overflow caused by the number P_r . Next a signal to memorise the data of the counter 21 in the register 24 is generated from the control circuit 25 and the data of 1's complement of the number P_r is memorised in the register 24. After clearing the counters 21, 22 again at the next timing, the control circuit 25 generates a signal to load the data in the register 24 in the counter 22.

Next, the resistance of the oscillation circuit is switched and the oscillation circuit oscillates at a frequency corresponding to the luminance. When a pulse is generated from the one shot pulse generating circuit, the counter 21 is supplied with pulses from the oscillation circuit and begins to count. The counter 21 loads data newly from the register 24 and counts repeatedly every time the counter 21 overflows. At the same time, the counter 22 increases by 1, so that it counts the number of times the counter 21 overflows. When the pulse from the one shot pulse generating circuit terminates, the integer part of P_r/P_x remains in the counter 22, and the decimal part remains in the

counter 21. This data is left in the register 23 by a signal from the control circuit 25 and then an exposure value corresponding to the luminance of the object of measurement is read out.

5 In the above described embodiments of the present invention it is possible to employ a capacitor having a relatively small capacitance and hence fabricate the photometric circuit in the form of an integrated circuit. Even if it is not formed as an integrated
10 circuit, it is possible to use a capacitor which is less costly. Moreover, it is possible to conduct photometric measurement with relatively high accuracy independently of temperature and power supply voltage fluctuations. Further, since the oscillation
15 frequency obtained when the photo-conductive element is connected as the frequency determining element increases as the luminance increases, the frequency ratio varies by a large margin in response to a slight change in luminance and it is, therefore, possible to perform
20 highly accurate photometric measurement even when the luminance is relatively high. In addition, since it is unnecessary to employ a comparator, the power supply voltage can be minimised.

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C L A I M S

1. A photometric circuit comprising: an oscillation
circuit having a resistor and a capacitor as frequency
5 determining elements; a photo-conductive element which,
in operation, responds to the luminance of an object of
measurement; a switching circuit for causing said
photo-conductive element to be selectively operatively
connected in said oscillation circuit so that said
10 photo-conductive element functions as a frequency
determining element; and a frequency ratio calculating
circuit for calculating the ratio of the oscillation
frequency obtained when said photo-conductive element is
operatively connected in said oscillation circuit, so as
15 to function as a frequency determining element to the
oscillation frequency obtained when said photo-
conductive element is not operatively connected in said
oscillation circuit.
2. A photometric circuit as claimed in claim 1 in
20 which the switching circuit is arranged so that the
resistor is operatively connected in the oscillation
circuit when the photo-conductive element is not
operatively connected in the oscillation circuit.
3. A photometric circuit as claimed in claim 1 in
25 which the switching circuit comprises a first switch for
short circuiting the photo-conductive element so that
the resistor is operatively connected with the
oscillation circuit and a second switch for short
circuiting the resistor so that the photo-conductive
30 element is operatively connected with the oscillation
circuit.
4. A photometric circuit substantially as herein
described with reference to and as shown in Figure 1 of
the accompanying drawings.



5. A photometric circuit substantially as herein described with reference to and as shown in Figure 1 as modified by Figure 3 of the accompanying drawings.

6. A photometric circuit substantially as herein described with reference to and as shown in Figures 1 and 5 of the accompanying drawings.

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