The present invention relates to a light emitting unit driving circuit and a light emitting device. The light emitting unit driving circuit provided according to embodiments of the invention includes: an operating voltage supplying unit for supplying a voltage input for the driving circuit; a driving unit coupled to the operating voltage supplying unit and configured to drive the light emitting unit to make the light emitting unit turn on or turn off; and a feedback control unit coupled between the driving unit and the light emitting unit, and forming a feedback loop together with the driving unit and the light emitting unit to stabilize an operating current of the light emitting unit.
LIGHT EMITTING UNIT DRIVING CIRCUIT AND
LIGHT EMITTING DEVICE

Field of the Invention

[0001] The present invention relates to a field of illumination, and particularly to a light emitting unit driving circuit and light emitting device.

Background of the Invention

[0002] Currently, in terms of driving for a light emitting unit, the driving for the light emitting unit (e.g., LED 1~LED N) is generally realized by using resistors connected with several light emitting units in series in low end application, as shown in Figure 1. Such scheme causes an output current to vary with variation of an input voltage, resulting in unstability or flicker of LEDs' brightness. In high end application, a pulse width modulation dimming integrated circuit (PWM IC), for example, a buck circuit and a boost circuit, is usually adopted. Such scheme has a high cost and circuit configuration is complicated.

[0003] Further, in terms of soft switching on/off of the light emitting unit, thermal inertia is utilized to realize soft switching on/off in some applications using an incandescent lamp in early times. At present, in order to realize a soft switching on/off function, a programmable microcontroller is often adopted to regulate a PWM control signal, and such scheme has a high cost.

[0004] Moreover, in terms of dimming of the light emitting unit, a controllable PWM IC is adopted widely, and an additional logical signal is used to perform dimming. Since an additional control signal is required, system design is complicated while the cost is high.

Summary of the Invention

[0005] Hereinafter, a brief summary about the invention is given to provide a basic understanding on some aspects of the invention. It should be appreciated that this summary is not an exhaustive summary of the invention. It is not intended to determine essential or important parts of the invention, nor does it intend to define the scope of the invention. An object thereof is merely to present some
concepts in a simplified form and hereby acts as a preamble of detailed
description which will be discussed later.

[0006] Based on the above problems, there is an urgent need for a solution that
can provide a constant output current for different input voltages. The inventor
proposes a light emitting unit driving circuit which solves at least one of problems
existing in the prior art described above and which has a simple configuration and
low cost.

[0007] According to an embodiment of the invention, there is provided a light
emitting unit driving circuit, which may include: an operating voltage supplying unit
for supplying a voltage input for the driving circuit; a driving unit coupled to the
operating voltage supplying unit and configured to drive the light emitting unit to
make the light emitting unit turn on or off; and a feedback control unit coupled
between the driving unit and the light emitting unit and forming a feedback loop
therewith to stabilize an operating current of the light emitting unit.

[0008] According to a preferred embodiment of the invention, the driving circuit
may further include a dimming unit coupled between the light emitting unit and the
feedback control unit and configured to regulate a current level of the feedback
control unit, and thereby dimming the light emitting unit.

[0009] According to a preferred embodiment of the invention, the driving circuit
may further include a switch unit and a soft switching on/off setting unit, which are
successively coupled in series between the operating voltage supplying unit and the
driving unit, in which the switch unit controls the soft switching on/off setting unit to
operate in a soft switching on setting state or a soft switching off setting state, so as
to control soft switching on or off of the light emitting unit.

[0010] Preferably, the driving unit may be configured to include a first transistor in
which a collector is connected to a positive input terminal of the operating voltage
supplying unit, an emitter is connected to the light emitting unit, and a base is
connected to a first control terminal of the feedback control unit via a first base
resistor and connected to the positive input terminal of the operating voltage
supplying unit via an input resistor.

[0011] Preferably, the feedback control unit may be configured to include a second
transistor in which a collector as the first control terminal is connected to the base of
the first transistor via the first base resistor, an emitter is connected to a negative
input terminal of the operating voltage supplying unit, and a base is connected to
one end of a dimming resistor via a second base resistor, the other end of the
dimming resistor being connected to the negative input terminal of the operating
voltage supplying unit, and wherein the feedback loop constituted by the first transistor, the first base resistor, the second transistor, the second base resistor and the light emitting unit is configured to stabilize the operating current of the light emitting unit.

As a preferred embodiment, the driving unit may be configured to include a first transistor in which a collector is connected to the positive input terminal of the operating voltage supplying unit, an emitter is connected to the light emitting unit, and a base is connected to a first setting terminal of the soft switching on/off setting unit via the first base resistor.

Preferably, the soft switching on/off setting unit may be configured to include a soft switching on setting loop constituted by a soft switching on setting resistor and a common soft switching on/off setting capacitor and a soft switching off setting loop constituted by a soft switching off setting resistor and the soft switching on/off setting capacitor, wherein in the soft switching on setting loop, the soft switching on setting resistor is connected between the first setting terminal of the soft switching on/off setting unit and one end of the switch unit, the other end of the switch unit being connected to the positive input terminal of the operating voltage supplying unit, and the soft switching on/off setting capacitor is connected between the first setting terminal and a second control terminal of the feedback control unit; and in the soft switching off setting loop, the soft switching off setting resistor is connected between the first setting terminal and the negative input terminal of the operating voltage supplying unit.

As another preferred embodiment, the feedback control unit may be configured to include a second transistor, a diode and a second base resistor, in which a collector of the second transistor is connected to a second setting terminal of the soft switching on/off setting unit via a second collector resistor, an emitter thereof is connected to the negative input terminal of the operating voltage supplying unit, a base thereof is connected to a negative end of the diode, a positive end of the diode being connected with one end of the second base resistor, the other end of the second base resistor being connected to a dimming control output terminal of the dimming unit, an operating voltage input terminal of the dimming unit being connected to the negative input terminal of the operating voltage supplying unit, a dimming input terminal of the dimming unit being connected to the light emitting unit, and the base of the second transistor as a second control terminal is further connected to the soft switching on/off setting capacitor of the soft switching on/off setting unit, and in which the diode is configured to prevent the soft switching on/off setting capacitor from discharging via
the second base resistor.

[0015] Preferably, the dimming unit may be configured to be a variable resistor connected between the light emitting unit and the negative terminal of the operating voltage supplying unit, so as to regulate the operating current of the feedback control unit and thereby dimming the light emitting unit.

[0016] According to another aspect of the invention, there is provided a light emitting device which may include at least one light emitting unit and the above-described driving circuit used to drive the at least one light emitting unit to operate.

[0017] Preferably, the above-described light emitting unit may be a LED.

[0018] The driving circuit provided according to the embodiments of the invention may realize a steady constant current output by feedback control with respect to any input voltage, and has a simpler configuration and a significantly reduced cost as compared with the PWM scheme in the prior art.

[0019] Furthermore, according to the embodiments provided by the invention, a soft switching on and off function of the light emitting unit may be realized on a basis of the constant current output, thus making human's eyes feel more comfortable.

[0020] Further, according to the embodiments provided by the invention, dimming of the light emitting unit may be performed while based on the constant current output.

[0021] In addition, according to the embodiments provided by the invention, dimming of the light emitting unit may be performed while a constant current output function and the soft switching on and off function of the light emitting unit are realized.

**Brief Description of the Drawings**

[0022] The above and other objects, characteristics and advantages of the invention will be better understood with reference to the description of embodiments of the invention given below in combination with the accompanying drawings. In the drawings, identical or corresponding technical features or components will be denoted by identical or corresponding reference numbers. The accompanying drawings together with the following detailed description are included in this specification and form a part of this specification, and serve to further illustrate preferred embodiments of the invention and to explain operation processes and
advantages of the invention by way of example. In the drawings:

[0023] Figure 1 is a schematic diagram of a light emitting unit driving circuit in the prior art;

[0024] Figure 2 illustrates a block diagram of a light emitting unit driving circuit according to an embodiment of the invention;

[0025] Figure 3 illustrates a block diagram of a light emitting unit driving circuit according to an embodiment of the invention;

[0026] Figure 4 illustrates a block diagram of a light emitting unit driving circuit according to an embodiment of the invention;

[0027] Figure 5 illustrates a block diagram of a light emitting unit driving circuit according to an embodiment of the invention;

[0028] Figure 6 illustrates a circuit diagram of a light emitting unit driving circuit according to an embodiment of the invention;

[0029] Figure 7 illustrates a circuit diagram of a light emitting unit driving circuit according to an embodiment of the invention; and

[0030] Figure 8 illustrates a circuit diagram of a light emitting unit driving circuit according to an embodiment of the invention;

Detailed Description of the Invention

[0031] Exemplary embodiments of the invention will be described in combination with the accompanying drawings hereinafter. For the sake of clarity and conciseness, not all the features of actual implementations are described in the specification. However, it should be appreciated that, numerous decisions specific to implementations must be made during development of any such actual embodiments, so as to achieve developers' specific goals, for example, compliance with system-related and business-related constraints which will vary from one implementation to another. Further, it should also be appreciated that, such a development effort might be very complex and time-consuming, but may nevertheless be a routine task for those skilled in the art having the benefit of this disclosure.

[0032] Herein, it shall further be noted that, for avoiding unnecessary details obscuring the invention, only device structures and/or processing steps closely relevant to schemes according to the invention are shown in the accompanying drawings while omitting other details less relevant to the invention.
LIGHT EMITTING UNIT DRIVING CIRCUIT

The First Implementation

[0033] Various embodiments of the invention are described in combination with the drawings below. Figure 2 illustrates a block diagram of a light emitting unit driving circuit according to an embodiment of the invention. In Figure 2, a driving circuit 200 includes an operating voltage supplying unit 201, a driving unit 204, a light emitting unit 206 and a feedback control unit 208. The operating voltage supplying unit 201 supplies a voltage input for the driving circuit 200, e.g., a direct current input. The driving unit 204 is coupled to the operating voltage supplying unit 201 and is configured to drive the light emitting unit 206, which may for example be a LED, so as to make the light emitting unit 206 turn on or turn off. The feedback control unit 208 is coupled between the driving unit 204 and the light emitting unit 206 and forms a feedback loop therewith to stabilize an operating current of the light emitting unit.

[0034] The operation process of the driving circuit 200 is described with reference to Figure 2 below. In this operation process, constant current output of the light emitting unit 206 is achieved by a closed cycle formed with the driving unit 204, the feedback control unit 208 and the light emitting unit 206. Specifically, after the operating voltage supplying unit 201 supplies a voltage input, a current passes through the driving unit 204 so that a current flowing via the light emitting unit 206 rises. Next, the current flowing via the light emitting unit 206 flows into the feedback control unit 208 to cause it to start operating. The feedback control unit 208 pulls down a current flowing into the driving unit 204 to cause it to stop operating, and thereby resulting in a decrease in a current flowing into the light emitting unit 206. In this case, the feedback control unit 208 is caused to stop operating due to the decrease in the current in the light emitting unit 206. While at this moment, the feedback control unit 208 no longer pulls down the current flowing into the driving unit 204 so that the current flowing into it increases, and the driving unit 204 starts operating, thus causing the current in the light emitting unit 206 to rise again. Thus, constant current output of the light emitting unit 206 is realized by the current cycle described above.

The Second Implementation

[0035] The constant current output is realized in the above-described first
implementation. As a preferred implementation of the above-described first implementation, an implementing manner, in which the light emitting unit is dimmed while the constant current output is achieved, is described in combination with Figure 3. Figure 3 illustrates a block diagram of a light emitting unit driving circuit according to an embodiment of the invention. In Figure 3, a driving circuit 300 includes an operating voltage supplying unit 301, a driving unit 304, a light emitting unit 306, a feedback control unit 308 and a dimming unit 307. The dimming unit 307 is coupled between the light emitting unit 306 and the feedback control unit 308 and is configured to regulate a current level of the feedback control unit 308 so as to realize dimming of the light emitting unit 306. The operating voltage supplying unit 301, driving unit 304, light emitting unit 306 and feedback control unit 308 may for example have same or similar structures and functions as the operating voltage supplying unit 201, driving unit 204, light emitting unit 206 and feedback control unit 208 as shown in Figure 2. For the sake of conciseness, no more description will be made herein.

[0036] Dimming process of the dimming unit 307 is described below. After the operating voltage supplying unit 301 supplies a voltage input, a current passes through the driving unit 304 so that a current flowing via the light emitting unit 306 rises. Next, the current flowing via the light emitting unit 306 flows into the dimming unit 307. The current flowing into the feedback control unit 308 may be controlled by regulating the dimming unit 307, and thus causing the feedback control unit 308 to start operating. The feedback control unit 308 pulls down a current flowing into the driving unit 304 to cause it to stop operating, and thereby resulting in a decrease in a current flowing into the light emitting unit 306. In this case, due to the decrease in the current in the light emitting unit 306, the feedback control unit 308 is caused to stop operating after the current flows via the dimming unit 307. While at this moment, the feedback control unit 308 no longer pulls down the current flowing into the driving unit 304 so that the current flowing into the driving unit 304 increases, and the driving unit 304 starts operating, thus causing the current in the light emitting unit 306 to rise again. Thus, the constant current output of the light emitting unit 306 is realized by the current cycle described above. Meanwhile, since the current flowing into the feedback control unit 308 can be controlled by regulating the dimming unit 307 so that current variation in the above-described cycle is controlled and the dimming process of the light emitting unit 306 is realized.

The Third Implementation

[0037] In the light emitting unit driving circuit, in addition to the requirement of
realization of constant current output, it is desired that soft switching on and soft switching off of the light emitting unit can be realized in order to provide the user with soft light emitting experience. That is, the current flowing via the light emitting unit (e.g., a LED) may be caused to have a varying curve rather than a spike after a switch operates (e.g., turns on or off). In other words, when the switch turns on and turns off, brightness of the light emitting unit may change gently rather than abruptly, thus making the human's eyes feel more comfortable.

[0038] An implementation for achieving soft switching on/off function of the light emitting unit is described in combination with Figure 4. Figure 4 illustrates a block diagram of a light emitting driving circuit according to an embodiment of the invention. A driving circuit 400 includes an operating voltage supplying unit 401, a switch unit 402, a soft switching on/off setting unit 403, a driving unit 404, a light emitting unit 406 and a feedback control unit 408. The switch unit 402 is coupled between the operating voltage unit supplying unit 401 and the driving unit 404. The soft switching on/off setting unit 403 is coupled between the switch unit 402 and the driving unit 404. The switch unit 402 controls the soft switching on/off setting unit 403 to operate in a soft switching on setting state or a soft switching off setting state. The operating voltage supplying unit 401, driving unit 404, light emitting unit 406 and feedback control unit 408 have same or similar structures and functions as the operating voltage supplying unit 201, driving unit 204, light emitting unit 206 and feedback control unit 208 as shown in Figure 2. For the sake of conciseness, no more description will be made herein.

[0039] An operation process for realizing soft switching on/off of the light emitting unit 406 by the soft switching on/off setting unit 403 is described below. After the switch unit 402 closes, an energy storage element in the soft switching on/off setting unit 403 stores charges to perform charging. Due to a shunting of the operation current caused by charging, as the charging amount increases, an input current of the driving unit 404 rises in a curve form, and an output current thereof also rises in a curve form, so that a current flowing via the light emitting unit 406 also rises in a curve form, and thus soft switching on of the light emitting unit 406 is realized. A time constant determined by a charging loop of the energy storage element defines a rate of soft switching on of the light emitting unit 406. After the above-described current cycle, the driving circuit 400 comes into a steady operating state, and achieves constant current output of the light emitting unit 406. After the switch unit 402 opens, electric quantity stored in the energy storage element in the soft switching on/off setting unit 403 maintains the input current of the driving unit 404, causing its output current to decrease in a curve form, so that the current
flowing via the light emitting unit 406 also decreases in a curve form, and thus soft switching off of the light emitting unit 406 is realized. Meanwhile, the energy storage element discharges through a discharge loop, and a time constant determined by the discharge loop defines a rate of soft switching off.

The Fourth Implementation

[0040] The preferred implementation in which the soft switching on/off function is further realized based on the second implementation has been described in the above-described third implementation. Next, a fourth implementation further having a dimming function is described in combination with Figure 5. Figure 5 illustrates a block diagram of a light emitting unit driving circuit according to an embodiment of the invention. In Figure 5, a driving circuit 500 includes an operating voltage supplying unit 501, a switch unit 502, a soft switching on/off setting unit 503, a driving unit 504, a light emitting unit 506, a feedback control unit 508 and a dimming unit 507. The dimming unit 507 is coupled between the light emitting unit 506 and the feedback control unit 508 and is configured to regulate a current level of the feedback control unit 508 so as to realize dimming of the light emitting unit 506. Structures and functions of the operating voltage supplying unit 501, driving unit 504, light emitting unit 506 and feedback control unit 508 may be for example identical or similar to the those of the operating voltage supplying unit 201, driving unit 204, light emitting unit 206 and feedback control unit 208 as shown in Figure 2. A structure and function of the dimming unit 507 may be for example identical or similar to those of the dimming unit 307 as shown in Figure 3. A structure and function of the soft switching on/off setting unit 503 may be for example identical or similar to those of the soft switching on/off setting unit 403 as shown in Figure 4. For the sake of conciseness, no more description will be made herein.

[0041] How the functions of constant current output, dimming and soft switching on/off of the light emitting unit are realized by the driving circuit 500 is described with reference to Figure 5 below. The operating voltage supplying unit 501 supplies the voltage input for the driving circuit 500. After the switch unit 502 closes, an energy storage element in the soft switching on/off setting unit 503 stores charges to perform charging. As the charging amount increases, an input current of the driving unit 504 rises in a curve form, and its output current also rises in a curve form, so that a current flowing via the light emitting unit 506 also rises in a curve form, and thus soft switching on of the light emitting unit 506 is realized. After the above-described current cycle, the driving circuit 500 comes into a steady operating state, and constant current output of the light emitting unit 506 is achieved. During
the current cycle, as mentioned above, it is possible to control a current flowing into the feedback control unit 508 by regulating the dimming unit 507, so that current variation in the cycle is controlled, and thus dimming process of the light emitting unit 506 is realized. After the switch unit 502 opens, electric quality stored in the energy storage element in the soft switching on/off setting unit 503 maintains an input current of the driving unit 504, causing its output current to decrease in a curve form, so that the current flowing via the light emitting unit 506 also decreases in a curve form, and thus soft switching off of the light emitting unit 506 is realized.

The Fifth Implementation

[0042] Four implementations of the invention are described in combination with Figures 2 to 5 above. One specific example of the above-described implementations is described in combination with a specific circuit example below. Figure 6 illustrates a circuit diagram of a light emitting unit driving circuit 600 of this example. The driving circuit 600 includes an operating voltage supplying unit 601, a driving unit 604, a feedback control unit 608 and a light emitting unit 606. It should be noted that, Figure 6 only illustrates a particular implementing manner provided according to the embodiment of the invention. Those skilled in the art may implement various alternative implementations of the invention according to the functional block diagram of the embodiment of the invention and by combining with the existing technology in the art that they master.

[0043] The operating voltage supplying unit 601 may for example supply a DC input. If an industrial standardized AC-DC conversion module is added, the operating voltage supplying unit 601 may also be spread to generate a DC voltage to be supplied based on an AC input. The driving unit 604 may include a first transistor Q1, in which a collector is connected to a positive input terminal DC in+ of the operating voltage supplying unit 601, an emitter is connected to the light emitting unit 606, and a base is connected to a first control terminal Ctrl1 (herein, a collector of a second transistor Q2 may be set to be the first control terminal Ctrl1) of the feedback control unit 608 via a first base resistor R3 and is connected to the positive input terminal DC in+ of the operating voltage supplying unit 601 via an input resistor R1. The first transistor Q1 may be a bipolar power transistor and serves as a linear amplifier tube with its characteristic of operating in a linear amplification region. The input resistor R1 is used to determine an operating point of the first transistor Q1.

[0044] The feedback control unit 608 may include a second transistor Q2, in which
a collector as the first control terminal is connected to the base of the first transistor Q1 via the first base transistor R3, an emitter is connected to a negative input terminal DC in- of the operating voltage supplying unit, and a base is connected to one end of a resistor R5 via a second base resistor R6, the other end of the resistor R5 being connected to the negative input terminal of the operating voltage supplying unit. On and off of the second transistor Q2 controls a current flowing into the base of the first transistor Q1, and thereby controlling on and off of the first transistor Q1. The second transistor Q2 may be a small package transistor, for example, on and off characteristic thereof serving as a base control tube of the first transistor Q1. The second base resistor R6 is used to determine an operating point of the second transistor Q2.

[0045] A feedback circuit constituted by the first transistor Q1 together with the second transistor Q2, the first base resistor R3 and the second base resistor R6 achieves a constant current output of an output terminal of the driving circuit, while consuming extra energy of the operating voltage supplying unit 601, this is because the voltage supplied by the operating voltage supplying unit 601 must be higher than the voltage of the light emitting unit 606.

[0046] An operation process of realizing constant current output of the light emitting unit by the driving circuit 600 is specifically described in combination with Figure 6 below. After the operating voltage supplying unit 601 supplies a voltage input, the input current causes a base current flowing into the first transistor Q1 to increase through an input resistor R1 and makes Q1 conduct, and subsequently, the light emitting unit 606 (for example may be a LED) begins illuminating. When the current flowing via the resistor R5 increases large enough, a current flowing into the second transistor Q2 via the second base resistor R6 is caused to increase so that the second transistor Q2 conducts. A collector current of the second transistor Q2 increases so that a base current flowing into the base of the first transistor Q1 is pulled down, causing the current flowing into the base of the first transistor Q1 via the first base resistor R3 to decrease, and thus the first transistor Q1 stops conducting. In this case, a current flowing into the light emitting unit 606 decreases, thereby a voltage on the resistor R5 decreases, so that the second transistor Q2 is caused to stop conducting. Thus, the second transistor Q2 no longer pulls down the current flowing into the base of the first transistor Q1, so that the base voltage of the first transistor Q1 rises and the first transistor Q1 conducts again, thus causing the current in the light emitting unit 606 to rise. Till now, the driving circuit 600 reaches a steady operating state and the constant current output is realized.

[0047] The resistor R5 in Figure 6 takes a constant value. However, as necessary,
the resistor R5 may be replaced with a variable resistor, or an additional variable resistor may be added to realize dimming of the light emitting unit, which will be described below.

The Sixth Implementation

[0048] A specific example of an implementation with a dimming function is described in combination with Figure 7 below. Figure 7 illustrates a circuit diagram of a light emitting unit driving circuit 700 according to a preferred embodiment of the invention. In Figure 7, the driving circuit 700 includes an operating voltage supplying unit 701, a driving unit 704, a feedback control unit 708, a light emitting unit 706 and a dimming unit 707. Structures and functions of the operating voltage supplying unit 701, driving unit 704, feedback control unit 708 and light emitting unit 706 may be for example identical or similar to those of the operating voltage supplying unit 601, driving unit 604, feedback control unit 608 and light emitting unit 606 as shown in Figure 6. For the sake of conciseness, no more description will be made herein.

[0049] An operating voltage input terminal a of the dimming unit 707 may be connected to a negative input terminal DC in- of the operating voltage supplying unit 701, a dimming control input terminal c of the dimming unit 707 may be connected to the light emitting unit 706, and a dimming control output terminal b of the dimming unit 707 may be connected to a second base resistor R6 of the feedback control unit 708. The dimming unit 707 may be implemented as a variable resistor R5'. The variable resistor R5' may be connected with the resistor R5 in series between the light emitting unit 706 and the negative terminal DC in- of the operating voltage supplying unit 701, so as to regulate a current level of the feedback control unit 708, and thus dimming of the light emitting unit 706 is realized. Specifically, after the operating voltage supplying unit 701 supplies a voltage input, a current causes a base current flowing into a first transistor Q1 (one specific example of the driving unit 704) to increase through an input resistor R1, thereby causing the first transistor Q1 to conduct, and subsequently, the light emitting unit 706 begins illuminating. When a current flowing via the variable resistor R5' increases large enough, a current flowing into the second transistor Q2 via the second base resistor R6 is caused to increase, thereby causing the second transistor Q2 to conduct. A collector current of the second transistor Q2 increases, so that a current flowing into the base of the first transistor Q1 is pulled down, and thus causing the current flowing into the base of the first transistor Q1 via a first base resistor R3 to decrease and the first transistor Q1 to stop conducting. In this
case, a current flowing into the light emitting unit 706 decreases, and thereby the voltage on the variable resistor R5' decreases, so that the second transistor Q2 is caused to stop conducing. Thus, the second transistor Q2 no longer pulls down the current flowing into the base of the first transistor Q1, so that the base voltage of the first transistor Q1 rises and the first transistor Q1 conducts again, and thus causing the current in the light emitting unit 706 to rise. Till now, the driving circuit 700 reaches a steady operating state and the constant current output is realized. 

Here, it is possible to regulate a current when the second transistor Q2 turns on and off by adjusting the value of the variable resistor R5', so that a current when the first transistor Q1 turns on and off is controlled, and thus dimming of the light emitting unit 706 is realized. It should be noted that, compared to a traditional dimming circuit, it is not to directly regulate the current flowing via the light emitting unit 706 here but to regulate the operating voltage of the feedback control unit 708, that is, an ON voltage of the second transistor Q2, by adjusting the value of the variable resistor R5', so that the current flowing via the light emitting unit 706 is regulated accordingly, and thus a dimming effect is achieved. Therefore, a resistor much smaller than a traditional dimming resistor may be adopted, so that energy consumption of the resistor itself is reduced. Certainly, the dimming unit 707 may be incorporated into the feedback control unit 708, for example, the resistor R5 and the variable resistor R5' may be incorporated together to form an alternative variable resistor R5"(not shown).

The Seventh Implementation

[0050] Now, on a basis that the constant current output of the driving circuit and the dimming of the light emitting unit are realized, how to realize the soft switching on/off function of the light emitting unit is described in combination with a circuit example of Figure 8. Figure 8 illustrates a circuit diagram of a light emitting unit driving circuit 800 according to a preferred embodiment of the invention. The driving circuit 800 includes an operating voltage supplying unit 801, a switch unit 802, a driving unit 804, a soft switching on/off setting unit 803, a light emitting unit 806, a dimming unit 807 and a feedback control unit 808.

[0051] As described above, the operating voltage supplying unit 801 may supply a DC input. The switch unit 802 may be a common single-pole single-throw switch SW1, and may also be for example a button switch, a slide switch or other types of switches. The driving unit 804 includes a first transistor Q1 in which a collector is connected to a positive input terminal DC in+ of the operating voltage supplying unit 801, an emitter is connected to the light emitting unit 806, and a base is connected
to a first setting terminal S1 of the soft switching on/off setting unit 803 via a
first base resistor R2. Here, a point close to R2 between the first base resistor R2
and a resistor R3 is set to be the first setting terminal S1. The first base resistor R2
is used to determine an operating point of the first transistor Q1.

[0052] The soft switching on/off setting unit 803 includes a soft switching on/off
setting capacitor which may be for example an energy storage capacitor C1, a soft
switching on setting resistor which may be for example a charging resistor R1, and
a soft switching off setting resistor which may be for example a discharging resistor
R4. The energy storage capacitor C1 forms a soft switching on setting loop with the
charging resistor R1, and forms a soft switching off setting loop with the discharging
resistor R4. The charging resistor R1 is connected between the first setting terminal
S1 and one end of the switch unit 802, the other end of the switch unit 802 being
connected to the positive input terminal of the operating voltage supplying unit 801,
and the energy storage capacitor C1 is connected between the first setting terminal
S1 and a second control terminal Ctrl2 of the feedback control unit 808. Here, a
point between the base of the second transistor Q2 and a negative end of a diode
D1 (as described later) may be set to be the second control terminal Ctrl2. The
discharging resistor R4 is connected between the first setting terminal S1 and a
negative input terminal DC in- of the operating voltage supplying unit 801.

[0053] An operating voltage input terminal a of the dimming unit 807 may be
connected to the negative input terminal DC in- of the operating voltage supplying
unit 801, a dimming control input terminal c of the dimming unit 807 may be
connected to the light emitting unit 806, and a dimming control output terminal b of
the dimming unit 807 may be connected to one end of a second base resistor R6
(as described later) of the feedback control unit 808. The dimming unit 807 may
include a variable resistor R5’. The variable resistor R5’ may be connected with a
resistor R5 in series between the light emitting unit 806 and the negative input
terminal DC in- of the operating voltage supplying unit 801.

[0054] The feedback control unit 808 includes the second transistor Q2, the diode
D1 and the second base resistor R6. A collector of the second transistor Q2 is
connected to a setting terminal S2 of the soft switching on/off setting unit at
a first control terminal Ctrl1 of the second transistor Q2 through a second collector
resistor R3, here, a point close to R3 between the first base resistor R2 and the
resistor R3 may be set to be the second setting terminal S2, an emitter thereof is
connected to the negative input terminal DC in- of the operating voltage supplying
unit, and a base thereof as the second control terminal is connected to the energy
storage capacitor C1 and the negative end of the diode D1, a positive end of the
diode D1 is connected with one end of the second base resistor R6, the other
end of the second base resistor R6 is connected to one end of the variable resistor
R5', and the other end of the variable resistor R5' may be connected with the
resistor R5 in series to the negative terminal DC in- of the operating voltage
supplying unit. The role of the diode D1 is to prevent the energy storage capacitor
C1 from discharging through the second base resistor R6 when the switch unit 802
opens.

[0055] An operation process of the driving circuit 800 is specifically described in
combination with Figure 8 below. The operating voltage supplying unit 801 supplies
the driving circuit 800 with a voltage input, e.g. a DC input. After the switch unit 82
closes, the energy storage element C1 charges through the input resistor R1 and
the second transistor Q2 (the base to the emitter). Due to the shunting effect of
charging of C1, during the rising of charging amount of C1, a base current flowing
into the first transistor Q1 via the first base resistor R2 rises in a logarithmic curve,
and its collector current rises in a logarithmic curve, so that the current flowing via
the light emitting unit 806 also rises in a logarithmic curve, and thus soft switching
on of the light emitting unit 806 is realized.

[0056] In the process of soft switching on of the light emitting unit 806, a voltage
on the variable resistor R5' rises, so that the current flowing into the second
transistor Q2 via the second base resistor R6 increases, and thus causing the
second transistor Q2 to conduct. Therefore, a collector current of the second
transistor Q2 increases, and a current flowing into the base of the first transistor Q1
via the first base resistor R2 decreases under the pulling down effect of the
collector current, thus causing the first transistor Q1 to stop conducting. In this case,
a current flowing into the light emitting unit 806 decreases, thereby the voltage on
the variable resistor R5' decreases, so that the second transistor Q2 is caused to
stop conducting. Since the second transistor Q2 no longer pulls down the current
flowing into the base of the first transistor Q1, a base voltage of the first transistor
Q1 rises, and the first transistor Q1 conducts again, causing the current in the light
emitting unit 806 to rise. Till now, the driving circuit 800 reaches a steady operating
state, and the constant current output is realized.

[0057] During the current cycle, as mentioned above, the base current of the
second transistor Q2 may be controlled by regulating the dimming unit 807(i.e., the
variable resistor R5' here), so that current variation in the cycle is controlled, and
thus dimming of the light emitting unit 806 is realized. Certainly, the dimming unit
807 may be incorporated into the feedback control unit 808, the resistor R5 and the
variable resistor R5' may be incorporated together to form an alternative variable
resistor (not shown), for example.

[0058] After the switch unit 802 opens, the energy storage capacitor $C_1$ is prevented from discharging via the second base resistor $R_6$ due to the existence of the diode $D_1$, and thus the electric quantity stored in the energy storage capacitor $C_1$ maintains the base current of the driving unit 804 (i.e., the first transistor $Q_1$). Therefore, the collector current of the first transistor $Q_1$ decreases in a logarithmic curve, causing the current flowing via the light emitting unit 806 also to decrease in a logarithmic curve, so that soft switching off of the light emitting unit 806 is realized. A time constant determined by the energy storage capacitor $C_1$ and the discharging resistor $R_4$ defines a rate of soft switching off.

[0059] Hereto, constant current output, soft switching on/off of the light emitting unit, as well as the dimming function of the light emitting unit are realized by the driving circuit 800.

[0060] It should be noted that, installation manner for the switch unit 802 is not limited if the soft switching on/off is not performed, for example, being installed at the input terminal of the operating voltage supplying unit or being omitted. If the soft switching on/off function is to be realized, the switch unit 802 should be installed in a base input circuit of the first transistor $Q_1$.

[0061] It should also be noted that, NPN-type transistors are adopted here for the transistors $Q_1$ and $Q_2$. This is only by way of example, and those skilled in the art may also use PNP-type transistors, and only the circuit configuration is required to be adjusted accordingly. Furthermore, other types of circuit configurations may also be used, as long as being able to serve as a linear amplifier.

[0062] Values of the resistors and capacitors in the RC loop realizing the soft switching on/off function in Figure 8 are not limited in theory, and may be taken in accordance with actual applications, for example, be taken in accordance with the rate of soft switching on/off required to be achieved. For example, assume that time for soft switching on is 1S, and time for soft switching off is 0.5S, then values of the resistors and the capacitors are as follows: $C_1$ is 22 $\mu$F, $R_1$ is 400 $\Omega$, $R_2$ is 500 $\Omega$, $R_3$ is 500 $\Omega$, and $R_4$ is 50 $k\Omega$. It should be noted that, the foregoing examples are only illustrative, and the present invention is not limited thereto. Those skilled in the art could design different parameter values in accordance with specific circuit requirements.

The Eighth Implementation
As another preferred implementation, the variable resistor R5' in the dimming unit 807 in Figure 8 may also be changed to be a constant resistor or be removed, realizing the constant current output of the driving circuit and the soft switching on/off function of the light emitting unit but not being used for dimming. Since operation processes of the driving circuit 600 for only constant current output and the driving circuit 700 for constant current output and dimming of the light emitting unit are described in Figure 6 and Figure 7 respectively, for the sake of conciseness, no more description will be made here.

**LIGHT EMITTING DEVICE**

According to the embodiment of the invention, there is further provided a light emitting device, which may include at least one light emitting unit and the above-described driving circuit for driving the at least one light emitting unit to operate.

Preferably, the light emitting unit may be a LED.

Several specific implementations for implementing the present invention are given above, intending to illustrate rather than limit the invention. The inventor describes multiple implementing manners in combination with specific circuits after proposing an overall conception. It should be noted that, these specific implementations are only illustrative, and those skilled in the art could take other alternative manners to complete the invention.

Finally, it also needs to illustrate that, the terms "includes," "including," or any other variation thereof are intended to cover a non-exclusive inclusion, such that an article or apparatus that includes series of elements includes not only those elements but also other elements not expressly listed or inherent to such article or apparatus. Further, an element proceeded by "includes a. . ." does not, without more constraints, preclude the existence of additional identical elements in the article or apparatus that comprises the element.

Although implementations of the present invention and advantages thereof have been described in combination with the accompanying drawings in detail, it should be appreciated that, the above described implementations are only used to explain the invention and are not constructed as limitations to the invention. Various modifications and alterations may be affected to the above described implementations by one skilled in the art without departing from the essential and scope of the invention. Therefore, the scope of the invention is defined by the
appended claims and equivalents thereof only, and various changes, replacements and transformations may be made without going beyond the spirit and scope of the invention defined by the appended claims.

Figure 2
201 operating voltage supplying unit
204 driving unit
206 light emitting unit
208 feedback control unit

Figure 3
301 operating voltage supplying unit
304 driving unit
306 light emitting unit
307 dimming unit
308 feedback control unit

Figure 4
401 operating voltage supplying unit
402 switch unit
403 soft switching on/off setting unit
404 driving unit
406 light emitting unit
408 feedback control unit

Figure 5
501 operating voltage supplying unit
502 switch unit
503 soft switching on/off setting unit
504 driving unit
506 light emitting unit
507 dimming unit
508 feedback control unit

Figure 6
601 operating voltage supplying unit
604 driving unit
606 light emitting unit
608 feedback control unit

Figure 7
701 operating voltage supplying unit
704 driving unit
706 light emitting unit
707 dimming unit
708 feedback control unit

Figure 8
801 operating voltage supplying unit
802 switch unit
803 soft switching on/off setting unit
804 driving unit
806 light emitting unit
807 dimming unit
808 feedback control unit
Claims:

1. A light emitting unit driving circuit, comprising:

   an operating voltage supplying unit configured to supply a voltage input for
   the driving circuit;

   a driving unit coupled to the operating voltage supplying unit and configured
   to drive the light emitting unit to make the light emitting unit turn on or turn off; and

   a feedback control unit coupled between the driving unit and the light
   emitting unit, and configured to form a feedback loop together with the driving circuit
   and the light emitting unit to stabilize an operating current of the light emitting unit.

2. The driving circuit as claimed in claim 1, further comprising:

   a dimming unit coupled between the light emitting unit and the feedback
   control unit and configured to regulate a current level of the feedback control unit so
   as to dim the light emitting unit.

3. The driving circuit as claimed in claim 1 or 2, further comprising:

   a switch unit and a soft switching on/off setting unit successively coupled in
   series between the operating voltage supplying unit and the driving unit, wherein
   the switch unit controls the soft switching on/off setting unit to operate in a soft
   switching on setting state or a soft switching off setting state so as to control soft
   switching on or off of the light emitting unit.

4. The driving circuit as claimed in claim 1 or 2, wherein the driving unit is
   configured to comprise a first transistor (Q1), a collector thereof being connected to
   a positive input terminal of the operating voltage supplying unit, an emitter thereof
   being connected to the light emitting unit, and a base thereof being connected to a
   first control terminal (Ctrl1) of the feedback control unit via a first base resistor (R3)
   and being connected to the positive input terminal of the operating voltage
   supplying unit via an input resistor (R1).

5. The driving circuit as claimed in claim 4, wherein the feedback control
   unit is configured to comprise a second transistor (Q2), a collector thereof as the
   first control terminal being connected to the base of the first transistor via the first
base resistor (R3), an emitter thereof being connected to a negative input
terminal of the operating voltage supplying unit, and a base thereof being
connected to one end of a dimming resistor (R5) via a second base resistor (R6),
the other end of the dimming resistor being connected to the negative input terminal
of the operating voltage supplying unit, and wherein the feedback loop constituted
by the first transistor, the first base resistor, the second transistor, the second base
resistor and the light emitting unit is configured to stabilize the operating current of
the light emitting unit.

6. The driving circuit as claimed in claim 3, wherein the driving unit is
configured to comprise a first transistor, a base thereof being connected to a
positive input terminal of the operating voltage supplying unit, an emitter thereof
being connected to the light emitting unit, and a base thereof being connected to a
first setting terminal (S1) of the soft switching on/off setting unit via a first base
resistor.

7. The driving circuit as claimed in claim 6, wherein the soft switching on/off
setting unit is configured to comprise a soft switching on setting loop constituted by
a soft switching on setting resistor and a common soft switching on/off setting
capacitor and a soft switching off setting loop constituted by a soft switching off
setting resistor and the soft switching on/off setting capacitor, wherein in the soft
switching on setting loop, the soft switching on setting resistor is connected
between the first setting terminal of the soft switching on/off setting unit and one
end of the switch unit, the other end of the switch unit being connected to the
positive input terminal of the operating voltage supplying unit, and the soft switching
on/off setting capacitor is connected between the first setting terminal and a second
control terminal (Ctrl2) of the feedback control unit; and in the soft switching off
setting loop, the soft switching off setting resistor is connected between the first
setting terminal and a negative input terminal of the operating voltage supplying
unit.

8. The driving circuit as claimed in claim 7, wherein the feedback control
unit is configured to comprise a second transistor, a diode and a second base
resistor, a collector of the second transistor being connected to a second setting
terminal (S2) of the soft switching on/off setting unit via a second collector resistor,
an emitter thereof being connected to the negative input terminal of the operating
voltage supplying unit, and a base thereof being connected to a negative end of the diode, a positive end of the diode being connected with one end of the second base resistor, the other end of the second base resistor being connected to a dimming control output terminal of the dimming unit, an operating voltage input terminal of the dimming unit being connected to the negative input terminal of the operating voltage supplying unit, a dimming input terminal of the dimming unit being connected to the light emitting unit, and the base of the second transistor as the second control terminal being further connected to the soft switching on/off setting capacitor of the soft switching on/off setting unit, and wherein the diode is configured to prevent the soft switching on/off setting capacitor from discharging via the second base resistor.

9. The driving circuit as claimed in claim 2, wherein the dimming unit is configured to be a variable resistor (R5'), which is connected between the light emitting unit and a negative terminal of the operating voltage supplying unit and is used to regulate an operating current of the feedback control unit so as to dim the light emitting unit.

10. An light emitting device comprising at least one light emitting unit and the driving circuit as claimed in any one of claims 1-9 for driving the at least one light emitting unit to operate.

11. The light emitting device as claimed in claim 10, wherein the light emitting unit is a LED.
A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Date of the actual completion of the international search: 17 November 2011
Date of mailing of the international search report: 05/12/2011

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