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(54) Method and apparatus for dimming a light source

Verfahren und Vorrichtung zum Abdimmen einer Lichtquelle

Procédé et appareil pour atténuer une source lumineuse

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(56) References cited:
WO-A1-2009/136328 DE-A1-102009 013 897
FR-A1- 2 931 616 US-A1- 2010 090 618

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Description

[0001] The invention relates to an apparatus and a method for dimming a light source in particular a linear light source comprising at least one light emitting diode LED or compact fluorescent lamp (CFL).

[0002] Conventional lamps such as incandescent lamps which transform heat into radiated light show a particular behaviour when dimmed by means of a dimmer such as a wall dimmer provided in a wall of a building. When reducing the light intensities of a light source, i.e. when dimming the light, the light intensity of the emitted light is reduced. At low light intensity the human eye is more sensitive for light variation. The eye-sensitivity of a human eye can be approximated by a logarithmic curve. With a linear light source doubling the amplitude of a control signal applied to this linear light source causes a doubling of the emitted light seen by the human eye. With a conventional incandescent lamp when a user entering for example a room within a building actuates a dimmer for example by turning a knob or moving sliding means of the dimmer for example halfway the user expects that the light level within the room will be reduced also by about 50%. With a conventional incandescent lamp transforming heat into emitting light the sensation of the user is indeed that the light level in the room is inherently about the half light level when comparing it with a light level before actuating the dimmer. Because of the logarithmic eye-sensitivity of the human eye if a conventional dimmer controlling a linear light source comprising for example light emitting diodes is actuated by a user entering a room for example halfway the caused light level which is perceived by the user in the room has a far too high light level.

[0003] DE 10 2009 013897 discloses a method and to a circuit arrangement for dimming an illuminant according to digital dimming values by regulation. In order to ensure that slow dimming is possible at high resolution, but the regulation takes place quickly at the same time, according to the invention the controller operates digitally but the target value/actual value comparison in the comparator takes place with analog signals. To this end, the digital dimming values are first converted to analog dimming values in a D/A converter. The analog control deviation ascertained by the analog operating comparator is then again converted by means of an A/D converter to a digital control deviation so that the digital controller can process it. The A/D converter must only process the control deviation-small, in comparison to the returned actual values-and ends up with a relatively low bit count. The D/A converter should additionally distort exponentially in order to compensate for the logarithmic dependence of the subjectively received brightness of the physically measurable light strength of the illuminant.

[0004] US 2010/090618 discloses an electromagnetic relay that enables current to pass through switch termini and comprises a coil assembly, a rotor or bridge assembly, and a switch assembly. The coil assembly comprises a coil and a C-shaped core. The coil is wound round a coil axis extending through the core. The core comprises core termini parallel to the coil axis. The bridge assembly comprises a bridge and an actuator. The bridge comprises medial, lateral, and transverse field pathways. The actuator extends laterally from the lateral field pathway. The core termini are coplanar with the axis of rotation and received intermediate the medial and lateral field pathways. The actuator is cooperable with the switch assembly. The coil creates a magnetic field directable through the bridge assembly via the core termini for imparting bridge rotation about the axis of rotation. The bridge rotation displaces the actuator for opening and closing the switch assembly.

[0005] FR 2 931 616 discloses a source device of an assembly of lightning devices that comprises a set of individual dimers each associated with a lightning device, the dimers delivering a first setpoint variable voltage and comprising means for generating from a first setpoint variable voltage and comprising means for generating from said first set a power signal pulse width modulated.

[0006] WO 2009/136328 discloses a driving circuit connected to a conventional phase-cut dimmer. A LED light source is driven by a switched mode power supply, which is powered by the mains voltage through a phase-cut dimmer and a rectifier. The current through the LED light source is reduced according to the voltage level of the average rectified voltage V_{in} detected by a voltage sensor and the on time limitation of the switched mode power supply. The current amplitude will be increasingly reduced towards the low voltage levels of V_{in} , namely towards the low dimmer knob levels. Thereby, the invention allows a LED light source driving circuit connected to a conventional phase-cut dimmer to readily make the dimming curve of the LED light source non-linear for being more compatible with the human eye sensitivity.

[0007] Accordingly, it is an object of the present invention to provide an apparatus and a method for dimming a linear light source, wherein a linear variation of a user actuated dimmer controlling a linear light source causes a corresponding light level sensation for the eyes of the actuating user. This object is achieved by an apparatus comprising the features of claim 1.

[0008] The invention provides an apparatus for dimming a light source which transforms with a transformation curve adapted to compensate a predetermined eye-sensitivity curve a varying input amplitude dimmer control signal provided by a dimmer into an output amplitude dimmer control signal applied to said light source.

[0009] The light source can be formed by a linear light source which can comprise at least one light emitting diode LED or a compact fluorescent lamp CFL.

[0010] In a possible embodiment of the apparatus according to the present invention the transformation curve provided by the apparatus is formed by a transformation curve having an exponential shape adapted to compensate a logarithmic

eye-sensitivity-curve of a human eye.

[0011] In a possible embodiment of the apparatus according to the present invention the apparatus comprises a signal transformation unit which transforms the varying input amplitude dimmer control signal into a pulse with modulated PWM-signal.

[0012] In a possible embodiment of the apparatus according to the present invention the apparatus further comprises a low pass filter which transforms the pulse with modulated PWM signal into the output amplitude dimmer control signal applied to the light source.

[0013] In a possible embodiment of the apparatus according to the present invention the signal transformation unit comprises a time base signal generator for generating a time base signal. In a possible embodiment of the apparatus according to the present invention the signal transformation unit further comprises a signal comparator which compares the generated time base signal with the varying input amplitude dimmer control signal to provide the pulse width modulated (PWM)-signal applied to the low pass filter.

[0014] In a possible embodiment of the apparatus according to the present invention the time base signal generator comprises at least one capacitor connected at a node via a resistor and/or a current source to a predetermined supply voltage of said signal transformation unit.

[0015] In a possible embodiment of the apparatus according to the present invention the voltage at the node of said time base signal generator is applied to a positive input of a voltage comparator having a negative input connected to a predetermined reference voltage close to the supply voltage.

[0016] In a possible embodiment of the apparatus according to the present invention an output of the voltage comparator activates means to precharge the capacitor of the time base signal generator to a start voltage causing the time base signal generator to act as an oscillator which generates a saw tooth signal with an exponential shape having a minimum voltage value equal to the start voltage and a maximum voltage level equal to the predetermined reference voltage.

[0017] In a possible embodiment of the apparatus according to the present invention the node of the time base signal generator is connected to a first input of the signal comparator which compares a voltage level of said node with a voltage level of the varying input amplitude dimmer control signal applied to a second input of the signal comparator to provide the pulse width modulated (PWM)-signal at an output of the signal comparator.

[0018] In a possible embodiment of the apparatus according to the present invention the signal comparator is supplied with a voltage difference having as a high level the upper supply voltage forming a maximum level of the transformation curve and having as a low level the lower supply voltage forming a minimum level of the transformation curve.

[0019] In a possible embodiment of the apparatus according to the present invention a ratio between a signal level of the varying input amplitude dimmer control signal and the predetermined supply voltage of the signal transformation unit corresponds to a light level provided by the light source.

[0020] In a possible embodiment of the apparatus according to the present invention the varying input amplitude dimmer control signal is a voltage dimmer control signal comprising a voltage level corresponding to a phase cut of a TRIAC transistor wall dimmer providing the voltage dimmer control signal.

[0021] In a possible embodiment of the apparatus according to the present invention the varying input amplitude dimmer control signal is a linear signal provided by an adjustable resistor divider that is connected to the supply voltage to generate an adjustable output voltage as the linear varying input amplitude dimmer control signal.

[0022] In a possible embodiment of the apparatus according to the present invention the low pass filter is a low pass filter of first or higher order comprising a predetermined corner frequency.

[0023] In a possible embodiment the low pass filter is a passive low pass filter.

[0024] In an alternative embodiment the low pass filter is an active low pass filter.

[0025] In a possible embodiment of the apparatus according to the present invention the corner frequency of the low pass filter is adapted to be low enough so that a spread of a switching frequency of the pulse width modulated (PWM)-signal and a spread of the corner frequency does not have an impact on the transformation curve.

[0026] The invention further provides a light emitting device comprising an apparatus for dimming a light source of said light emitting device wherein said apparatus transforms with a transformation curve adapted to compensate a predetermined eye-sensitivity-curve a linear varying input amplitude dimmer control signal provided by a dimmer into an output amplitude dimmer control signal applied to the light source of said light emitting device.

[0027] In a possible embodiment of the light emitting device according to the present invention the light source of the light emitting device is formed by a linear light source comprising at least one light emitting diode LED or a compact fluorescent lamp CFL or any other linear light source.

[0028] In a possible embodiment of the light emitting device according to the present invention the light emitting device further comprises a mains-low-pass-filter which transforms a phase cut dimmer control signal provided by the dimmer into the linear varying input amplitude dimmer control signal.

[0029] The invention further provides a method for dimming a light source comprising the features of claim 17.

[0030] The invention provides a method for dimming a light source wherein a varying input amplitude dimmer control signal provided by a dimmer is transformed with a transformation curve adapted to compensate a predetermined eye-

sensitivity-curve into an output amplitude dimmer control signal applied to the light source.

[0031] The method according to the present invention can be used for dimming a linear light source comprising light emitting diodes or compact fluorescent lamps.

[0032] In the following embodiments of the apparatus and method for dimming a light source are described with reference to the enclosed figures in more detail.

Fig. 1 shows a block diagram of a possible embodiment of an apparatus for dimming a light source according to the present invention;

Fig. 2 shows a circuit diagram for illustrating a possible embodiment of a signal transformation unit as employed by the apparatus for dimming a light source as shown in Fig. 1;

Fig. 3A, 3B show signal diagrams for illustrating a possible embodiment for a signal transformation unit as employed by an apparatus for dimming a light source according to a possible embodiment;

Fig. 4 shows a diagram for illustrating the functionality of an apparatus for dimming a light source according to the present invention;

Fig. 5 shows a further diagram for illustrating the functionality of an apparatus for dimming a light source according to possible embodiments of the present invention;

Fig. 6 shows a block diagram of a possible embodiment of a light emitting device according to the present invention;

Fig. 7 shows a signal diagram for illustrating a functionality of a light emitting device according to a possible embodiment.

Fig. 8 shows a diagram of a circuit generating a current as employed by a time base signal generator used by the apparatus according to the present invention.

[0033] As can be seen in Fig. 1 an apparatus 1 according to a possible embodiment of the present invention is provided for dimming a light source 2, in particular a linear light source such as a light emitting diode LED for a compact fluorescent lamp CFL. The apparatus 1 transforms a varying input amplitude dimmer control signal IADCS provided by a dimmer 3 into an output amplitude dimmer control signal OADCS applied to the light source 2. The apparatus 1 provides a transformation curve to compensate a predetermined eye-sensitivity-curve of a human eye of a user. By means of this transformation curve the varying input amplitude dimmer control signal IADCS provided by the dimmer 3 is transformed by the apparatus 1 into the output amplitude dimmer control signal OADCS applied by the apparatus 1 to the light source 2. In the shown embodiment of Fig. 1 the apparatus 1 forms a separate device connected between the dimmer 3 and the light source 2. In an alternative embodiment the apparatus 1 can be integrated in the dimmer 3. In a still further embodiment the apparatus 1 can be integrated in a light emitting device or lamp comprising the light source 2.

[0034] As can be seen in Fig. 1 the apparatus 1 comprises a signal transformation unit 4 and a low pass filter 5. The signal transformation unit 4 comprises a time base signal generator 4A generating a time base signal TBS to a signal comparator 4B comparing the time base signal TBS with the varying input amplitude dimmer control signal IADCS provided by the dimmer 3. The output of the signal comparator 4 is formed by a pulse width modulated PWM-signal supplied to the low pass filter 5. The signal transformation unit 4 transforms the varying input amplitude dimer control signal IADCS into the pulse width modulated PWM-signal applied to the low pass filter 5 which transforms the received pulse width modulated PWM-signal into the output amplitude dimmer control signal OADCS applied by the apparatus 1 to the light source 2.

[0035] Fig. 2 shows a possible embodiment of the signal transformation unit 4 within the apparatus 1. In the shown implementation of Fig. 2 the time base signal generator 4A comprises at least one capacitor C connected at a node N via a resistor R to a predetermined supply voltage V_{DD} . The time base signal generator further comprises in a possible embodiment a current source supplying the node N with a adjustable supply current I_s . The voltage at the node N of the time base signal generator 4A as shown in Fig. 2 is applied to a positive input of a voltage comparator which can be formed by an operation amplifier opAmp. The voltage comparator comprises a negative input which is connected to a predetermined reference voltage V_{stop} ($V_{stop} > V_{start}$) which can be close to the supply voltage V_{DD} of the signal transformation unit 4. The output of the voltage comparator controls means for precharging the capacitor C of the time base signal generator 4A to a start voltage V_{Start} . The means for precharging the capacitor C is formed in the shown embodiment by a switch SW being controlled by the output of the operational amplifier opAmp. The time base signal

generator 4A as shown in Fig. 2 acts as an oscillator which generates a saw tooth signal with an exponential shape as a time base signal TBS having a minimum voltage value equal to the start voltage V_{Start} and a maximum voltage V_{stop} being equal or close to the predetermined reference voltage.

[0036] Fig. 3A shows a signal diagram for illustrating the time base signal TBS generated by a time base signal generator 4A as shown in Fig. 2. In the shown embodiment the generated time base signal TBS is a periodically signal and in particular a saw tooth signal with an exponential shape similar to a shark fin as shown in Fig. 3A. The exponential time base signal is generated by the time base signal generator 4A through charging the capacitor C by applying a voltage by means of the resistor R shown in Fig. 2.

[0037] The generated time base signal TBS is supplied to the signal comparator 4B which can be formed in the embodiment shown in Fig. 2 also by an operational amplifier opAmp. The signal comparator 4B compares the generated time base signal TBS with the varying input amplitude dimmer control IADCS to provide the pulse width modulated signal PWM supplied to the low pass filter 5. In the shown embodiment of Fig. 2 the node N of the time base signal generator 4A is connected to a first input of the signal comparator 4B which compares the voltage level at the node N with a voltage level of the varying input amplitude dimmer control signal IADCS applied to a second (negative) input of the signal comparator 4B to provide the pulse width modulated signal PWM at an output of the signal comparator 4B. As can be seen in Fig. 2 the signal comparator 4B is supplied with a voltage difference having as a high level the upper supply voltage forming a maximum of the transformation curve and having as a low level the lower supply voltage forming a minimum level of the transformation curve.

[0038] Fig. 3B shows a pulse width modulated PWM signal generated by the signal comparator 4B within the signal transformation unit 4. With the apparatus 1 according to the present invention the transformation curve TC is generated for transforming the input signal to the pulse width modulated PWM signal using a time base reference signal TBS having the exponential shape as shown in Fig. 3A. Consequently a linear varying input amplitude dimmer control signal IADCS is changed to a pulse width modulated PWM signal with an exponential varying duty cycle.

[0039] The time reference signal is transferred back to an amplitude signal through the low pass filter 5 thus providing an exponential transfer function or transformation curve TC for transforming the input signal to the output signal.

[0040] The low pass filter 5 of the compensation apparatus 1 integrates the pulse width modulated (PWM) signal:

$$V_{out} = \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} V_{PWM} \cdot dt \quad \begin{cases} KT < t < ton + KT & V_{PWM} = V_{max} \\ ton + KT < t < KT + T & V_{PWM} = V_{min} \end{cases} \quad (1)$$

[0041] The resulting transfer function or compensation curve provided by the apparatus 1 has an exponential shape to compensate a logarithmic eye-sensitivity-curve of a human eye. Accordingly, the transformation curve TC provided by the apparatus 1 is an inverse logarithmic curve having a small output voltage variation at a low input voltage and having a higher output voltage variation for larger input voltage.

[0042] In the embodiment of Fig. 2 the capacitor C of the time base signal generator 4A is charged with a current depending on the voltage $V_{DD} + I_S \cdot R$ and the resistance value of the resistor R thus creating an exponential capacitor voltage as an exponential time reference signal:

$$V_c(t) = (V_{DD} + I_S \cdot R) \cdot \left[1 - \left(1 - \frac{V_{start}}{V_{DD} + I_S \cdot R} \right) e^{\frac{-t}{RC}} \right] \quad (2)$$

[0043] The capacitor C of the time base signal generator 4A is charged to a predetermined end voltage level V_{Stop} . When the capacitor C reaches this end voltage level V_{Stop} the capacitor C is discharged to the starting voltage V_{Start} and the cycle starts again as shown in Fig. 3A. The stop voltage V_{Stop} determines the period T of the pulse width modulated PWM signal wherein the period T is the time in which the capacitor C is charged from the starting voltage V_{Start} to the stop voltage V_{Stop} . The stop voltage level V_{Stop} also determines the start point of the dimming curve, i.e. when no dimming is performed. The output signal of the signal comparator 4B is the pulse width modulated PWM signal which is a square wave signal having an amplitude comprising a low voltage level V_{min} and a high voltage level V_{max} and having a period of T as well as a duty cycle of ton/T . For the on-time ton the output voltage is V_{max} and for the off-time or remaining time the output voltage is V_{min} .

[0044] The average output voltage of the pulse width modulated PWM signal is the exponential reference voltage:

$$V_{OUT} = \frac{1}{T} \int_0^T V_{PWM} dt = \frac{ton}{T} (V_{max} - V_{min}) + V_{min} \quad (3)$$

with:

(4)

$$\frac{ton}{T} = \frac{\ln(VDD + IsR - VDIM) - \ln(VDD + IsR - Vstart)}{\ln(VDD + IsR - Vstop) - \ln(VDD + IsR - Vstart)} = \frac{\ln(VDD + IsR - VDIM)}{c2 - c1} - \frac{c1}{c2 - c1}$$

and with $ton/T=0$ when the dimming level $VDIM$ level ($= IADCS$) $\leq V_{Start}$ and $ton/T=1$ when $VDIM$ level $\geq V_{Stop}$, wherein $C1$ and $C2$ are constants.

[0045] The current Is can be generated with a VI converter as shown in Fig. 8 with a reference voltage, V_{ref} , and a converting resistor, R_{VI} , matched to the resistor R in the Time Base Signal Generator 4A. This results in that $Is \cdot R$ in the

Time Base block 4A is mainly dependent on the V_{ref} voltage of the VI converter, $Is \cdot R = V_{ref} \cdot \frac{R}{R_{VI}}$, and therefore

insensitive to temperature changes and process spread of the resistors.

[0046] If $\ln(VDD + IsR - VDIM) > C1$ the transfer function TC is more exponentially curved and when

[0047] $\ln(VDD + IsR - VDIM) < C1$ the transfer function TC is a more linear function as can be seen in the diagram of Fig. 5.

[0048] Fig. 5 shows an exemplary duty cycle with $V_{Start}=1V$, $V_{Stop}=3V$, $V_{DD}+IsR=3,2V$ or $4V$, wherein $VDIM$ is $1V$ to $3V$. According to the linearity of the shown transformation curve TC is defined by circuit design having a maximum light level of 100% and a minimum light level of about 5%.

[0049] Fig. 4 shows a diagram for illustrating the functionality of the apparatus and method for dimming a light source according to the present invention.

[0050] Within the first quarter I of the shown diagram the logarithmic eye-sensitivity-curve ESC of a human eye is compensated by a transformation curve TC having an exponential shape adapted to compensate the logarithmic eye-sensitivity curve ESC of the human eye. This transformation curve TC having an exponential shape is shown in the second quarter II of the diagram. The apparatus 1 according to the present invention is designed to provide the transformation curve TC in quarter II which has an exponential shape adapted to compensate the logarithmic eye-sensitivity-curve ESC shown in the first quarter I. As can be seen from the diagram in Fig. 4 a linear variation of an actuator such as a turning knob of a dimmer leads to a linear change of the eye perception of the human eye and allows an easy control of the light setting for a user. A linear variation of the dimmer leads as shown in Fig. 4 to a linear varying input amplitude dimmer control signal IADCS applied to the compensation apparatus 1 according to the present invention as shown in Fig. 1. To linearize the control of the light perception the transformation of the linear varying input amplitude control signal IADCS to the output amplitude dimmer control signal OADCS is done by means of an exponential transformation curve TC as shown in the second quarter II of Fig. 4. For instance, if a human user changes the degree of a turning knob of dimmer from e.g. 45° to 135° this causes in the shown exemplary embodiment a variation of the output amplitude dimmer control signal OADCS from 25% of the supply voltage to 75% of the supply voltage. In the exemplary embodiment as shown in Fig. 4 the transfer from the turning knob (actuator degree ϕ) to the dimming voltage or input amplitude dimmer control signal IADCS is set to a linear curve. In alternative embodiments this curve can also be non-linear. For example when using a TRIAC dimmer the transfer from the turning knob degree to the phase cut of the sine wave can be non-linear, i.e. the dimming voltage has a linear relationship with the phase cut.

[0051] In a preferred embodiment of the apparatus 1 according to the present invention the slope of the exponential transformation curve TC shown in the second quarter II of the diagram shown in Fig. 4 is adaptable. The form of the transformation curve TC shown in the second quarter II has an exponential shape which can be adapted to compensate the logarithmic eye-sensitivity-curve ESC of the human eye.

[0052] Fig. 5 shows a duty cycle of the pulse width modulated PWM signal depending on the dimming voltage provided by the dimmer, i.e. the varying input amplitude dimmer control signal IADCS. The slope and linearity of the curve shown in Fig. 4 depends on the circuit design of the compensation apparatus 1 and in particular of the signal transformation unit 4 shown in Fig. 1. By changing the value of the resistor R and the currents S as provided by the integrated current

source of the time base signal generator as well as by changing the supply voltage V_{DD} the slope and form of the curve can be adapted.

[0053] In a possible embodiment the circuit element of the time base signal generator 4A and the signal comparator S4B within the signal transformation unit 4, i.e. the resistor R, the capacitor C, the current source as well as the operation amplifiers OpAmp are integrated into an integrated circuit IC. In a possible embodiment at least some circuit elements such as the resistor R and the capacitor C of the time base signal generator 4A can be formed by discrete circuit elements connected to an integrated circuit. In a still further embodiment some circuit parameters such as the resistance value of the resistor R and/or the capacitance of the capacitor C and the current amplitude of the current generated by the current source are adaptable, i.e. they can be set by a user to change the transformation curve TC shown in Fig. 5. In the shown exemplary embodiment of Fig. 5 the supply voltage V_{DD} for the signal transformation unit 4 has 4V and the dimming voltage can be varied between 1V and 3V corresponding to 25% and 75% of the supply voltage V_{DD} . In the shown exemplary embodiment the maximum light level (100%) corresponds to a voltage setting of 3V and the minimum light level (5%) has a set voltage of 1V. Depending on the circuit design in particular depending on the resistance value of the resistor R and the current amplitude of the current source the shape of the transformation curve TC can be more linear or more bent depending on the logarithmic eye-sensitivity-curve ESC of the human eye of different users.

[0054] Using a pulse width modulated PWM signal to generate the transformation curve TC with an exponential shape has the advantages that the dimming curve mainly depends on the accuracy of the applied supply voltage V_{DD} . The start and end value voltage of the dimming curve can easily set with the amplitudes, V_{min} to V_{max} , of the pulse width modulated PWM signal and are independent of the transfer function.

[0055] The transfer from a high dimming setting to a low dimming setting is a transfer function TC with an exponential shape whereby the transfer function only depends on the accuracy to detect the voltage references (speed comparators) and on the accuracy of the voltage references.

[0056] A further advantage is that a temperature dependency and process dependency and a component spread of circuit components such as a resistor R and capacitor C within the time base signal generator 4A do only affect the period time T, however, do not affect the duty cycle of the pulse width modulated PWM signal.

[0057] With the apparatus 1 according to the present invention a ratio between a signal level of the varying input amplitude dimmer control signal IADCS and the predetermined supply voltage V_{DD} of said signal transformation unit 4 corresponds to a light level provided by the light source 2.

[0058] The signal transformation unit 4 as shown in Fig. 1 applies a pulse width modulated PWM signal to the low pass filter 5. The low pass filter 5 is formed in a possible embodiment by an active low pass filter. In an alternative embodiment the low pass filter 5 can also be formed by a passive low pass filter. In a possible embodiment the low pass filter 5 can be also integrated along with the signal transformation unit 4 in an integrated circuit IC. In a possible embodiment the low pass filter 5 is a low pass filter of first order comprising a predetermined corner frequency. In a still further possible embodiment the low pass filter 5 is a filter of second or higher order comprising a predetermined corner frequency. The corner frequency of the low pass filter 5 is adapted to be low enough so that a spread of a switching frequency of the pulse width modulated signal PWM supplied to the low pass filter 5 by the signal transformation unit 4 and a spread of the corner frequency does not have an impact of the transformation curve TC which compensates the logarithmic eye-sensitivity-curve ESC of the human eye.

[0059] Fig. 6 shows a block diagram of a possible embodiment of a light-emitting device 6 comprising a compensation apparatus 1 for dimming a light source 2 integrated in the light emitting device 6. The light emitting device 6 as shown in Fig. 6 is a light lamp or an illuminating device comprising one or several light sources 2 wherein each light source 2 can receive a control signal from a corresponding compensation apparatus 1. Accordingly, the light emitting device 6 can comprise more than one compensation apparatus 1 and more than one light source 2. The light source 2 can be formed by a linear light source comprising for example a light emitting diode LED or a compact fluorescent lamp CFL. The compensation apparatus 1 as shown in Fig. 6 can control one light source 2 or at the same time several light sources 2 connected in parallel to the low pass filter 5. In the shown embodiment of Fig. 6 the light emitting device 6 further comprises a mains-low-pass-filter 7 which transforms a phase cut dimmer control signal provided by the dimmer 3 to provide as a linear input amplitude dimmer control signal IADCS applied to the signal transformation unit 4. The cut off of the mains-low-pass-filter 7 can in a possible embodiment be less than 100 Hz.

[0060] Fig. 7 shows a signal diagram for a phase cut signal PCS applied by a dimmer 3 such as a TRIAC dimmer. As can be seen in the signal diagram of Fig. 7 the signal is a phase cut rectified sign wave supply voltage having in the shown example an amplitude of 340 V and a period of $t=10$ ms. The dim level voltage can be in a range from 0 to the supply voltage V_{DD} :

$$VDIMLVL = \frac{\varphi}{180^\circ} \cdot VDD \quad (5)$$

[0061] For a phase lower than 45° the output voltage represents a minimum dim level. Accordingly, the minimum voltage V_{min} of the pulse width modulated PWM signal is the minimum dim level and the start voltage V_{Start} is $1/4 V_{DD}$. In a possible embodiment for a phase higher than 135° the output voltage is maximal so that the maximum voltage V_{max} of the pulse width modulated signal is the maximal voltage and the stop voltage V_{Stop} is $3/4 V_{DD}$. The minimum dim level is 5% of the maximal output level.

(6)

$$\frac{ton}{T} = \frac{\ln(VDD + IsR - VDIM) - \ln(VDD + IsR - \frac{1}{4}VDD)}{\ln(VDD + IsR - \frac{3}{4}VDD) - \ln(VDD + IsR - \frac{1}{4}VDD)} = \frac{\ln(VDD + IsR - VDIM) - c1}{c2}$$

or with $\alpha \cdot VDD = Is \cdot R$

$$\frac{ton}{T} = \frac{\ln(1 + \alpha - \frac{VDIM}{VDD}) - c3}{c4}, \quad 1/4VDD < VDIM < 3/4VDD$$

[0062] The accuracy of the curves mainly depends on the accuracy of the reference supply voltage V_{DD} , Is generated with a VI converter with R_{VI} matched to R of time generator block 4A. The VDD voltage is constructed with the same reference voltage which is used in the VI converter.

[0063] In a possible embodiment the reference supply voltage V_{DD} is 4 V, resulting in a start voltage $V_{Start} = 1V$ and a stop voltage $V_{Stop} = 3V$ for the time base signal generator 4A. In a possible embodiment the maximum output voltage $VPWM_{max}$ is set to 2 V resulting in 100 mV (5% of $VPWM_{max}$) for $VPWM_{min}$.

$$VDIM_{LVL} \leq V_{start}, \quad VLOG = 0.1V$$

$$V_{start} \leq VDIM_{LVL} \leq V_{stop}, \quad VLOG = 0.1 + \frac{ton}{T} \cdot (2 - 0.1) \quad (7)$$

$$VDIM_{LVL} \geq V_{stop}, \quad VLOG = 2V$$

[0064] The apparatus 1 for dimming the light source 2 according to the present invention as shown in the embodiment of Fig. 1 can be implemented in a possible embodiment by an analogue circuitry as shown in Fig. 2. In a possible embodiment the apparatus 1 for dimming a light source 2 by a compensation transformation curve TC can be implemented in the digital domain. The compensation apparatus 1 as shown in Fig. 1 can be implemented by an integrated circuit or a discrete circuitry. The compensation apparatus 1 according to the present invention can also be integrated in a light emitting device 6 having one or several linear light sources 2. In a possible embodiment the dimmer 3 is located in a wall of a building. In a still further embodiment the dimmer 3 can also be integrated in the light emitting device 6 having a compensation apparatus 1 according to the present invention. Further, it is possible that the compensation apparatus 1 as well as the mains-low-pass-filter 7 as shown in Fig. 6 are integrated in a dimmer 3 for dimming a light source 2.

[0065] The invention provides also a method for dimming a light source 2 wherein a varying input dimmer control signal IADCS provided by a dimmer 3 is transformed with a transformation curve adapted to compensate a predetermined eye-sensitivity-curve ESC into an output amplitude dimmer control signal OADCS applied to the light source 2.

[0066] In a possible embodiment the eye-sensitivity-curve ESC of a human eye is measured and stored in a data base or data memory. In a possible embodiment the measured eye-sensitivity-curve ESC of a human eye is read-out of the data memory and a corresponding matching transformation curve TC is calculated. This transformation curve TC has an exponential shape adapted to compensate the logarithmic eye-sensitivity-curve ESC of the human eye read from

the data memory. In a possible embodiment the design parameters of the signal transformation unit 4 in particular the values of the resistance of the resistor R and the generate current by the current source as well as the supply reference voltage V_{DD} are selected or programmed such that the transformation curve TC is adapted to compensate the measured logarithmic eye-sensitivity-curve ESC of the human eye which can be an individual ESC curve of a specific user. In a possible embodiment the resistance value of the resistor R, the current amplitude generated by the DC current source of the time base signal generator 4A as well as the reference supply voltage V_{DD} are adaptable and are set in such a way that the resulting transformation curve TC is adapted to compensate the measured eye-sensitivity-curve ESC of the human eye of a user.

Claims

1. An apparatus (1) for dimming a light source (2) which transforms with a transformation curve (TC) adapted to compensate a predetermined eye-sensitivity-curve (ESC) a varying input amplitude-dimmer-control signal (IADCS) provided by a dimmer (3) into an output amplitude dimmer control signal (OADCS) applied to said light source (2), the apparatus **characterised in that** it comprises:
 - a signal transformation unit (4) which transforms said varying input amplitude dimmer control signal (IADCS) into a pulse width modulated (PWM)-signal and
 - a low pass filter (5) which transforms the pulse width modulated (PWM)-signal into said output amplitude dimmer control signal (OADCS) applied to said light source (2).
2. The apparatus according to claim 1, wherein said transformation curve (TC) is formed by a transformation curve having an exponential shape adapted to compensate a logarithmic eye-sensitivity-curve (ESC) of a human eye.
3. The apparatus according to claims 1 to 2, wherein said signal transformation unit (4) comprises a time base signal generator (4A) for generating a time base signal (TBS) and a signal comparator (4B) which compares the generated time base signal (TBS) with the varying input amplitude dimmer control signal (IADCS) to provide said pulse width modulated (PWM)-signal supplied to said low pass filter (5).
4. The apparatus according to claim 3, wherein said time base signal generator (4A) comprises at least one capacitor (C) connected at a node (N) via a resistor (R) and/or a current source to a predetermined supply voltage (V_{DD}) of said signal transformation unit (4).
5. The apparatus according to claim 4, wherein the voltage at said node (N) of said time base signal generator (4A) is applied to a positive input of a voltage comparator having a negative input connected to a predetermined reference voltage close to the supply voltage (V_{DD}), wherein an output of said voltage comparator activates means (SW) to precharge said capacitor (C) of said time base signal generator (4A) to a start voltage (V_{start}) causing said timebase signal generator (4A) to act as an oscillator which generates a sawtooth signal with an exponential shape having a minimum voltage value equal to the start voltage (V_{start}) and a maximum voltage level (V_{stop}) equal to the predetermined reference voltage.
6. The apparatus according to claim 4, wherein said node (N) of said time base signal generator (4A) is connected to a first input of the signal comparator (4B) which compares a voltage level at said node (N) with a voltage level of said varying input amplitude dimmer control signal (IADCS) applied to a second input of said signal comparator (4B) to provide said pulse width modulated (PWM)-signal at an output of said signal comparator (4B).
7. The apparatus according to claim 6, wherein said signal comparator (4B) is supplied with a voltage difference having as a high level the upper supply voltage forming a maximum level of said transformation curve (TC) and having as a low level the lower supply voltage forming a minimum level of said transformation curve (TC).
8. The apparatus according to claims 1 to 7, wherein a ratio between a signal level of said varying input amplitude dimmer control signal (IADCS) and said predetermined supply voltage (V_{DD}) of said signal transformation unit (4) corresponds to a light level provided by said light source (2).
9. The apparatus according to claims 1 to 8, wherein said varying input amplitude dimmer control signal (IADCS) is a voltage dimmer control signal comprising a voltage level corresponding to a phase cut of a TRIAC transistor wall

dimmer providing said voltage dimmer control signal.

10. The apparatus according to claim 1 to 7,
wherein said varying input amplitude dimmer control signal (IADCS) is a linear signal provided by an adjustable resistor divider that is connected to the supply voltage (V_{DD}) to generate an adjustable output voltage as the linear varying input amplitude dimmer control signal (IADCS).
11. The apparatus according to claims 1 to 10, wherein said low pass filter (5) is a low pass filter of first or second order comprising a predetermined corner frequency.
12. The apparatus according to claim 11, wherein the corner frequency of said low pass filter (5) is adapted to be low enough so that a spread of a switching frequency of said pulse width modulated (PWM)-signal and a spread of said corner frequency does not have an impact on said transformation curve (TC).
13. A light emitting device (6) comprising an apparatus (1) according to one of the preceding claims 1 to 12.
14. The light emitting device (6) according to claim 13, wherein said light source (2) is formed by a linear light source comprising at least one light emitting diode (LED) or a compact fluorescent lamp (CFL) or any other linear light source.
15. The light emitting device (6) according to claims 13 or 14, wherein said light emitting device (6) further comprises a mains-low-pass-filter (7) which transforms a phase cut dimmer control signal provided by said dimmer (3) into said linear varying input amplitude dimmer control signal (IADCS).
16. A method for dimming a light source (2) wherein a varying input amplitude dimmer control signal (IADCS) provided by a dimmer (3) is transformed with a transformation curve (TC) adapted to compensate a predetermined eye-sensitivity-curve (ESC) into an output amplitude dimmer control signal (OADCS) applied to said light source (2), the method **characterised in that** it comprises transforming, by a signal transformation unit (4), said varying input amplitude dimmer control signal (IADCS) into a pulse width modulated (PWM)-signal and transforming, by a low pass filter (5), the pulse width modulated (PWM)-signal into said output amplitude dimmer control signal (OADCS) applied to said light source (2).

Patentansprüche

1. Vorrichtung (1) zum Dimmen einer Lichtquelle (2), die mit einer Transformationskurve (Transformation Curve, TC), die dafür angepasst ist, eine zuvor festgelegte Augenempfindlichkeitskurve (Eye Sensitivity Curve, ESC) zu kompensieren, ein variierendes Eingangsamplitudendimmer-Steuersignal (Input Amplitude Dimmer Control Signal, IADCS), das durch einen Dimmer (3) bereitgestellt wird, in ein Ausgangsamplitudendimmer-Steuersignal (Output Amplitude Dimmer Control Signal, OADCS), das an die Lichtquelle (2) angelegt wird, transformiert.
wobei die Vorrichtung **dadurch gekennzeichnet ist, dass** sie Folgendes umfasst:
 - eine Signaltransformationseinheit (4), die das variierende Eingangsamplitudendimmer-Steuersignal (IADCS) in ein impulsbreitenmoduliertes (pulse width modulated, PWM) Signal transformiert, und
 - einen Tiefpassfilter (5), der das impulsbreitenmodulierte (PWM) Signal in das an die Lichtquelle (2) angelegte Ausgangsamplitudendimmer-Steuersignal (OADCS) transformiert.
2. Vorrichtung nach Anspruch 1, wobei die Transformationskurve (TC) durch eine Transformationskurve gebildet wird, die eine Exponentialform aufweist, die dafür angepasst ist, eine logarithmische Augenempfindlichkeitskurve (ESC) eines menschlichen Auges zu kompensieren.
3. Vorrichtung nach den Ansprüchen 1 bis 2, wobei die Signaltransformationseinheit (4) Folgendes umfasst: einen Zeitbasissignalgenerator (4A) zum Generieren eines Zeitbasissignals (Time Base Signal, TBS) und einen Signalkomparator (4B), der das generierte Zeitbasissignal (TBS) mit dem variierenden Eingangsamplitudendimmer-Steuersignal (IADCS) vergleicht, um das impulsbreitenmodulierte (PWM) Signal bereitzustellen, das in das Tiefpassfilter (5) eingespeist wird.

4. Vorrichtung nach Anspruch 3, wobei der Zeitbasissignalgenerator (4A) mindestens einen Kondensator (C) umfasst, der an einem Knoten (N) über einen Widerstand (R) und/oder eine Stromquelle mit einer zuvor festgelegten Versorgungsspannung (V_{DD}) der Signaltransformationseinheit (4) verbunden ist.
5. Vorrichtung nach Anspruch 4, wobei die Spannung an dem Knoten (N) des Zeitbasissignalgenerators (4A) an einen positiven Eingang eines Spannungskomparators angelegt wird, der einen negativen Eingang aufweist, der mit einer zuvor festgelegten Bezugsspannung nahe der Versorgungsspannung (V_{DD}) verbunden ist, wobei ein Ausgang des Spannungskomparators ein Mittel (SW) aktiviert, um den Kondensator (C) des Zeitbasissignalgenerators (4A) auf eine Anfangsspannung (V_{start}) vorzuladen, was dazu führt, dass der Zeitbasissignalgenerator (4A) als ein Oszillator fungiert, der ein Sägezahnsignal mit einer Exponentialform generiert, das einen Mindestspannungswert gleich der Anfangsspannung (V_{start}) und einen Maximalspannungspegel (V_{stop}) gleich der zuvor festgelegten Bezugsspannung aufweist.
6. Vorrichtung nach Anspruch 4, wobei der Knoten (N) des Zeitbasissignalgenerators (4A) mit einem ersten Eingang des Signalkomparators (4B) verbunden ist, der einen Spannungspegel an dem Knoten (N) mit einem Spannungspegel des variierenden Eingangsamplitudendimmer-Steuersignals (IADCS) vergleicht, das in einen zweiten Eingang des Signalkomparators (4B) eingespeist wird, um das impulsbreitenmodulierte (PWM) Signal an einem Ausgang des Signalkomparators (4B) bereitzustellen.
7. Vorrichtung nach Anspruch 6, wobei in den Signalkomparator (4B) eine Spannungsdifferenz eingespeist wird, der als einen hohen Pegel die obere Versorgungsspannung hat, die einen Höchstpegel der Transformationskurve (TC) bildet, und als einen niedrigen Pegel die untere Versorgungsspannung hat, die einen Mindestpegel der Transformationskurve (TC) bildet.
8. Vorrichtung nach den Ansprüchen 1 bis 7, wobei ein Verhältnis zwischen einem Signalpegel des variierenden Eingangsamplitudendimmer-Steuersignals (IADCS) und der zuvor festgelegten Versorgungsspannung (V_{DD}) der Signaltransformationseinheit (4) einem Lichtwert entspricht, der durch die Lichtquelle (2) ausgegeben wird.
9. Vorrichtung nach den Ansprüchen 1 bis 8, wobei das variierende Eingangsamplitudendimmer-Steuersignal (IADCS) ein Spannungsdimmersteuersignal ist, das einen Spannungspegel umfasst, der einem Phasenschnitt eines TRIAC-Transistor-Wanddimmers entspricht, der das Spannungsdimmersteuersignal bereitstellt.
10. Vorrichtung nach den Ansprüchen 1 bis 7, wobei das variierende Eingangsamplitudendimmer-Steuersignal (IADCS) ein lineares Signal ist, das durch einen verstellbaren Widerstandsteiler bereitgestellt wird, der mit der Versorgungsspannung (V_{DD}) verbunden ist, um eine verstellbare Ausgangsspannung als das lineare variierende Eingangsamplitudendimmersteuersignal (IADCS) zu generieren.
11. Vorrichtung nach den Ansprüchen 1 bis 10, wobei das Tiefpassfilter (5) ein Tiefpassfilter erster oder zweiter Ordnung ist, das eine zuvor festgelegte Eckfrequenz umfasst.
12. Vorrichtung nach Anspruch 11, wobei die Eckfrequenz des Tiefpassfilters (5) dafür angepasst ist, niedrig genug zu sein, so dass eine Spreizung einer Schaltfrequenz des impulsbreitenmodulierten (PWM) Signals und eine Spreizung der Eckfrequenz keine Auswirkung auf die Transformationskurve (TC) haben.
13. Lichtaussendevorrichtung (6), die eine Vorrichtung (1) nach einem der vorangehenden Ansprüche 1 bis 12 umfasst.
14. Lichtaussendevorrichtung (6) nach Anspruch 13, wobei die Lichtquelle (2) durch eine lineare Lichtquelle gebildet wird, die mindestens eine Leuchtdiode (Light Emitting Diode, LED) oder eine kompakte Leuchtstofflampe (Compact Fluorescent Lamp, CFL) oder eine sonstige lineare Lichtquelle umfasst.
15. Lichtaussendevorrichtung (6) nach den Ansprüchen 13 oder 14, wobei die Lichtaussendevorrichtung (6) des Weiteren ein Netzstrom-Tiefpassfilter (7) umfasst, das ein Phasenschnittdimmer-Steuersignal, das durch den Dimmer (3) bereitgestellt wird, in das lineare variierende Eingangsamplitudendimmer-Steuersignal (IADCS) transformiert.
16. Verfahren zum Dimmen einer Lichtquelle (2), wobei ein variierendes Eingangsamplitudendimmer-Steuersignal (IADCS), das durch einen Dimmer (3) bereitgestellt wird, mit einer Transformationskurve (Transformation Curve, TC), die dafür angepasst ist, eine zuvor festgelegte Augenempfindlichkeitskurve (Eye Sensitivity Curve, ESC) zu

kompensieren, in ein Ausgangsamplitudendimmer-Steuersignal (Output Amplitude Dimmer Control Signal, OADCS), das an die Lichtquelle (2) angelegt wird, transformiert wird, das an die Lichtquelle (2) angelegt wird, wobei das Verfahren **dadurch gekennzeichnet ist, dass** es Folgendes umfasst:

- Transformieren, durch eine Signaltransformationseinheit (4), des variierenden Eingangsamplitudendimmer-Steuersignals (IADCS) in ein impulsbreitenmoduliertes (PWM) Signal, und
- Transformieren, durch ein Tiefpassfilter (5), des impulsbreitenmodulierten (PWM) Signals in das Ausgangsamplitudendimmer-Steuersignal (OADCS), das an die Lichtquelle (2) angelegt wird.

Revendications

1. Appareil (1) de gradation d'une source de lumière (2) qui transforme, avec une courbe de transformation (TC) adaptée pour compenser une courbe de sensibilité de l'oeil (ESC) prédéterminée, un signal de commande de gradateur d'amplitude d'entrée (IADCS) variable fourni par un gradateur (3) en un signal de commande de gradateur d'amplitude de sortie (OADCS) appliqué à ladite source de lumière (2), l'appareil étant **caractérisé en ce qu'il** comprend :
 - une unité de transformation de signal (4) qui transforme ledit signal de commande de gradateur d'amplitude d'entrée (IADCS) variable en un signal de modulation de largeur d'impulsion (PWM) et
 - un filtre passe-bas (5) qui transforme le signal de modulation de largeur d'impulsion (PWM) en ledit signal de commande de gradateur d'amplitude de sortie (OADCS) appliqué à ladite source de lumière (2).
2. Appareil selon la revendication 1, dans lequel ladite courbe de transformation (TC) est formée par une courbe de transformation ayant une forme exponentielle adaptée pour compenser une courbe de sensibilité de l'oeil (ESC) logarithmique d'un oeil humain.
3. Appareil selon les revendications 1 à 2, dans lequel ladite unité de transformation de signal (4) comprend un générateur de signal de base de temps (4A) pour générer un signal de base de temps (TBS) et un comparateur de signaux (4B) qui compare le signal de base de temps (TBS) généré au signal de commande de gradateur d'amplitude d'entrée (IADCS) variable pour fournir ledit signal de modulation de largeur d'impulsion (PWM) fourni audit filtre passe-bas (5).
4. Appareil selon la revendication 3, dans lequel ledit générateur de signal de base de temps (4A) comporte au moins un condensateur (C) connecté au niveau d'un noeud (N) par l'intermédiaire d'une résistance (R) et/ou d'une source de courant à une tension d'alimentation prédéterminée (V_{DD}) de ladite unité de transformation de signal (4).
5. Appareil selon la revendication 4, dans lequel la tension au niveau dudit noeud (N) dudit générateur de signal de base de temps (4A) est appliquée à une entrée positive d'un comparateur de tension ayant une entrée négative connectée à une tension de référence prédéterminée proche de la tension d'alimentation (V_{dd}), dans lequel une sortie dudit comparateur de tension active un moyen (SW) pour précharger ledit condensateur (C) dudit générateur de signal de base de temps (4A) à une tension de démarrage (V_{start}) amenant ledit générateur de signal de base de temps (4A) à agir comme un oscillateur qui génère un signal en dents de scie avec une forme exponentielle ayant une valeur de tension minimale égale à la tension de démarrage (V_{start}) et un niveau de tension maximum (V_{stop}) égal à la tension de référence prédéterminée.
6. Appareil selon la revendication 4, dans lequel ledit noeud (N) dudit générateur de signal de base de temps (4A) est connecté à une première entrée du comparateur de signaux (4B) qui compare un niveau de tension au niveau dudit noeud (N) à un niveau de tension dudit signal de commande de gradateur d'amplitude d'entrée (IADCS) variable appliqué à une seconde entrée dudit comparateur de signaux (4B) pour fournir ledit signal de modulation de largeur d'impulsion (PWM) au niveau d'une sortie dudit comparateur de signaux (4B).
7. Appareil selon la revendication 6, dans lequel ledit comparateur de signaux (4B) reçoit une différence de tension ayant comme niveau haut la tension d'alimentation supérieure formant un niveau maximum de ladite courbe de transformation (TC) et ayant comme niveau bas la tension d'alimentation inférieure formant un niveau minimum de ladite courbe de transformation (TC).

8. Appareil selon les revendications 1 à 7, dans lequel un rapport entre un niveau de signal dudit signal de commande de gradateur d'amplitude d'entrée (IADCS) variable et ladite tension d'alimentation prédéterminée (V_{DD}) de ladite unité de transformation de signal (4) correspond à un niveau d'éclairage fourni par ladite source de lumière (2).

9. Appareil selon les revendications 1 à 8, dans lequel ledit signal de commande de gradateur d'amplitude d'entrée (IADCS) variable est un signal de commande de gradateur de tension comprenant un niveau de tension correspondant à une coupure de phase d'un gradateur mural à transistor TRIAC fournissant ledit signal de commande de gradateur de tension.

10. Appareil selon la revendication 1 à 7, dans lequel ledit signal de commande de gradateur d'amplitude d'entrée (IADCS) variable est un signal linéaire fourni par un diviseur de résistance réglable qui est connecté à la tension d'alimentation (V_{DD}) pour générer une tension de sortie réglable en tant que signal de commande de gradateur d'amplitude d'entrée (IADCS) variable linéaire.

11. Appareil selon les revendications 1 à 10, dans lequel ledit filtre passe-bas (5) est un filtre passe-bas du premier ou du second ordre comprenant une fréquence coin prédéterminée.

12. Appareil selon la revendication 11, dans lequel la fréquence coin dudit filtre passe-bas (5) est adaptée pour être suffisamment faible pour que la propagation d'une fréquence de commutation dudit signal de modulation de largeur d'impulsion (PWM) et une propagation de ladite fréquence coin n'aient pas d'impact sur ladite courbe de transformation (TC).

13. Dispositif d'émission de lumière (6) comprenant un appareil (1) selon l'une quelconque des revendications précédentes 1 à 12.

14. Dispositif d'émission de lumière (6) selon la revendication 13, dans lequel ladite source de lumière (2) est formée par une source de lumière linéaire comprenant au moins une diode électroluminescente (LED) ou une lampe fluorescente compacte (LFC) ou n'importe quelle autre source de lumière linéaire.

15. Dispositif d'émission de lumière (6) selon la revendication 13 ou 14, dans lequel ledit dispositif d'émission de lumière (6) comprend en outre un filtre passe-bas du réseau (7) qui transforme un signal de commande de gradateur de coupure de phase fourni par ledit gradateur (3) en ledit signal de commande de gradateur d'amplitude d'entrée (IADCS) variable linéaire.

16. Procédé de gradation d'une source de lumière (2) dans lequel un signal de commande de gradateur d'amplitude d'entrée (IADCS) variable fourni par un gradateur (3) est transformé avec une courbe de transformation (TC) adaptée pour compenser une courbe de sensibilité de l'oeil (ESC) prédéterminée en un signal de commande de gradateur d'amplitude de sortie (OADCS) appliqué à ladite source de lumière (2), le procédé étant **caractérisé en ce qu'il** comprend :

- la transformation, par une unité de transformation de signal (4), dudit signal de commande de gradateur d'amplitude d'entrée (IADCS) variable en un signal de modulation de largeur d'impulsion (PWM) et
- la transformation, par un filtre passe-bas (5), du signal de modulation de largeur d'impulsion (PWM) en ledit signal de commande de gradateur d'amplitude de sortie (OADCS) appliqué à ladite source de lumière (2).

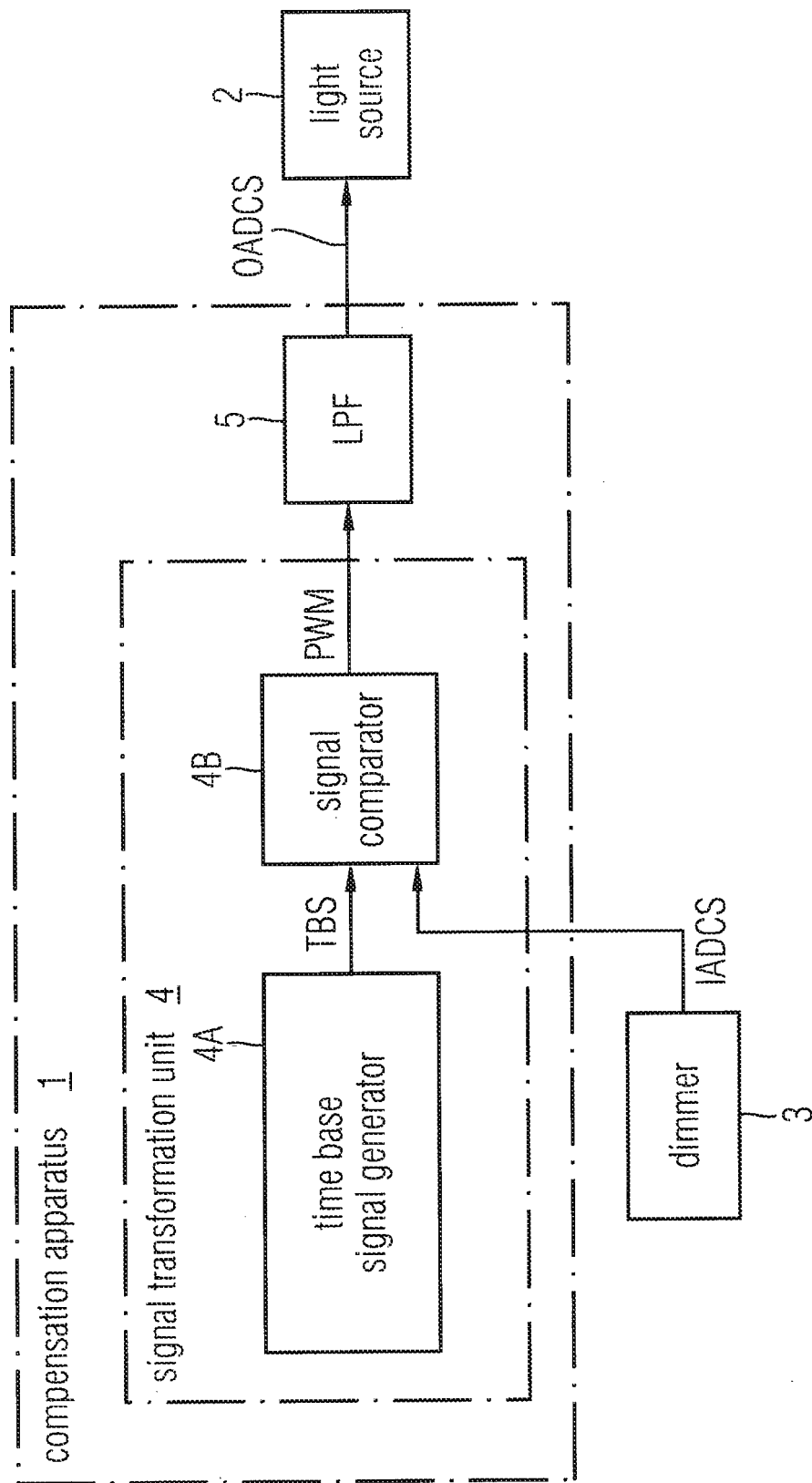


Fig. 1

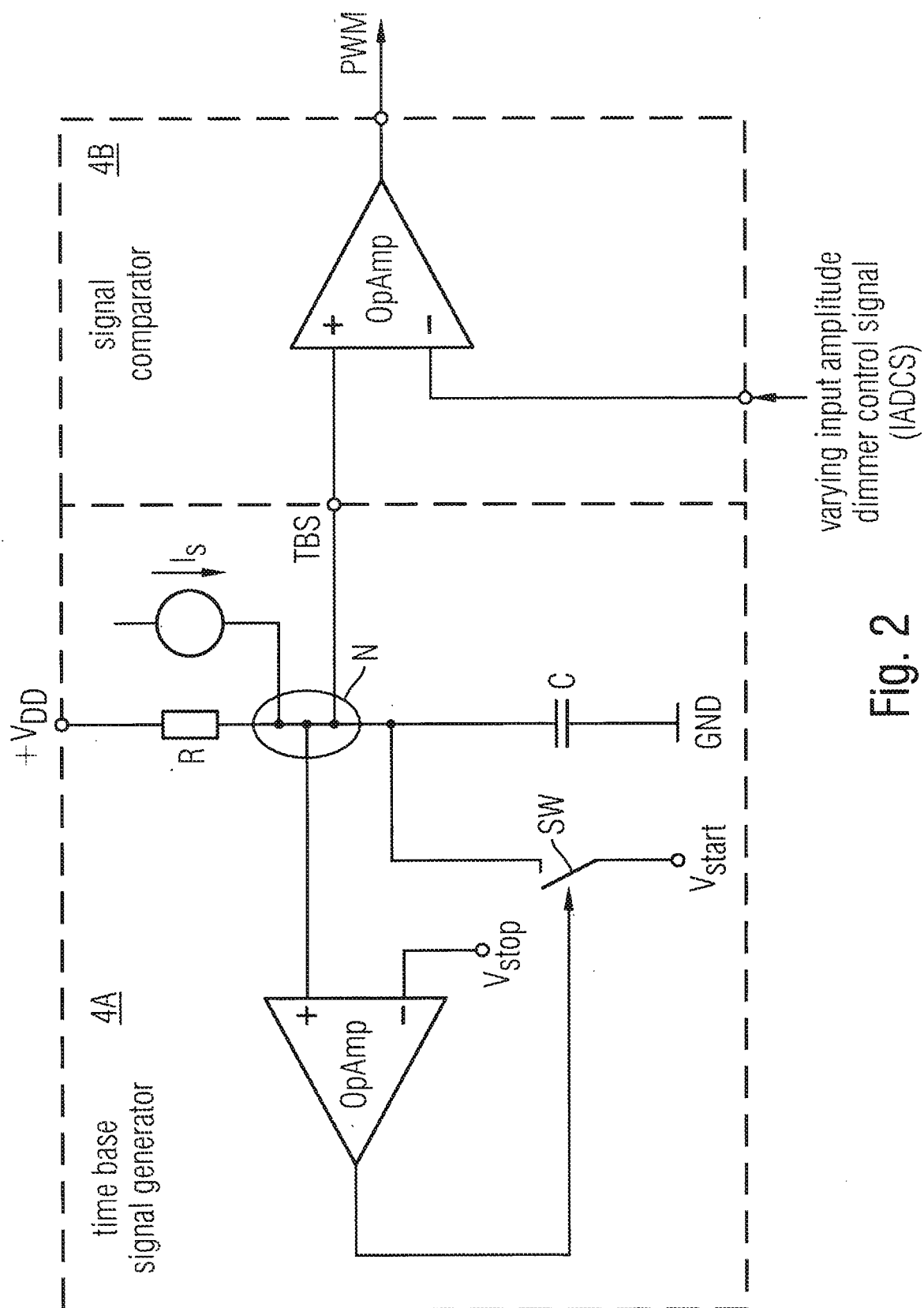


Fig. 2

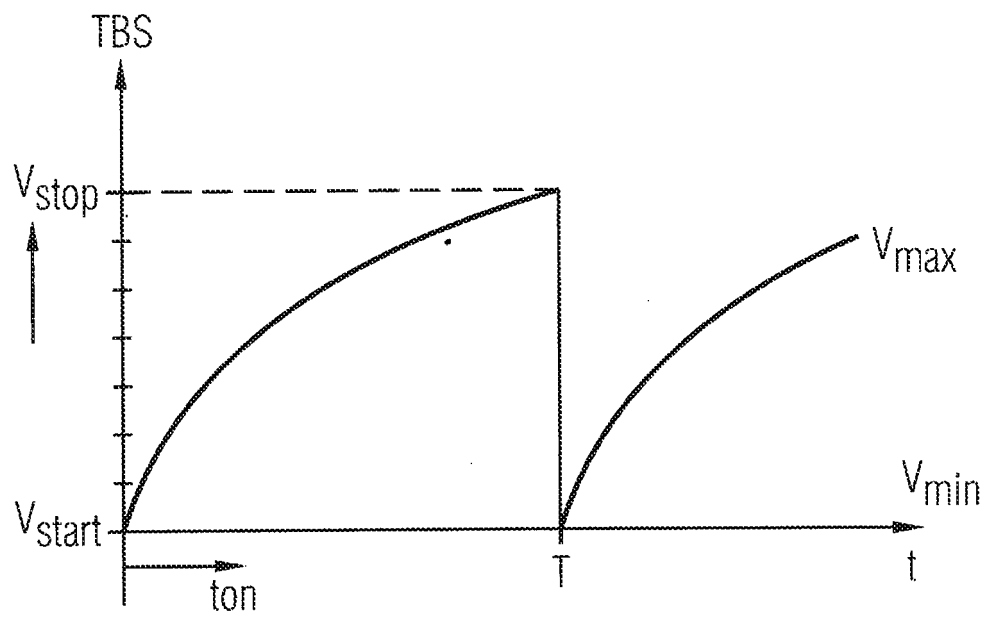


Fig. 3A

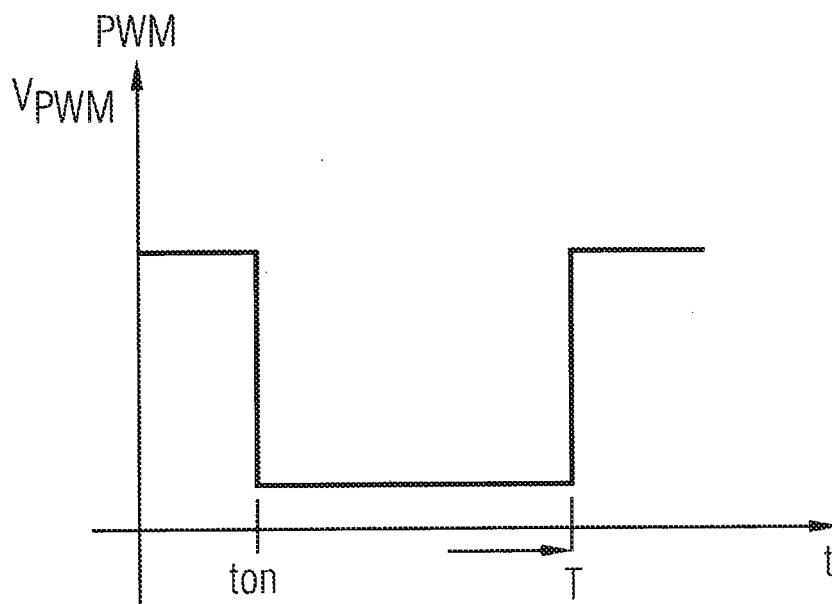


Fig. 3B

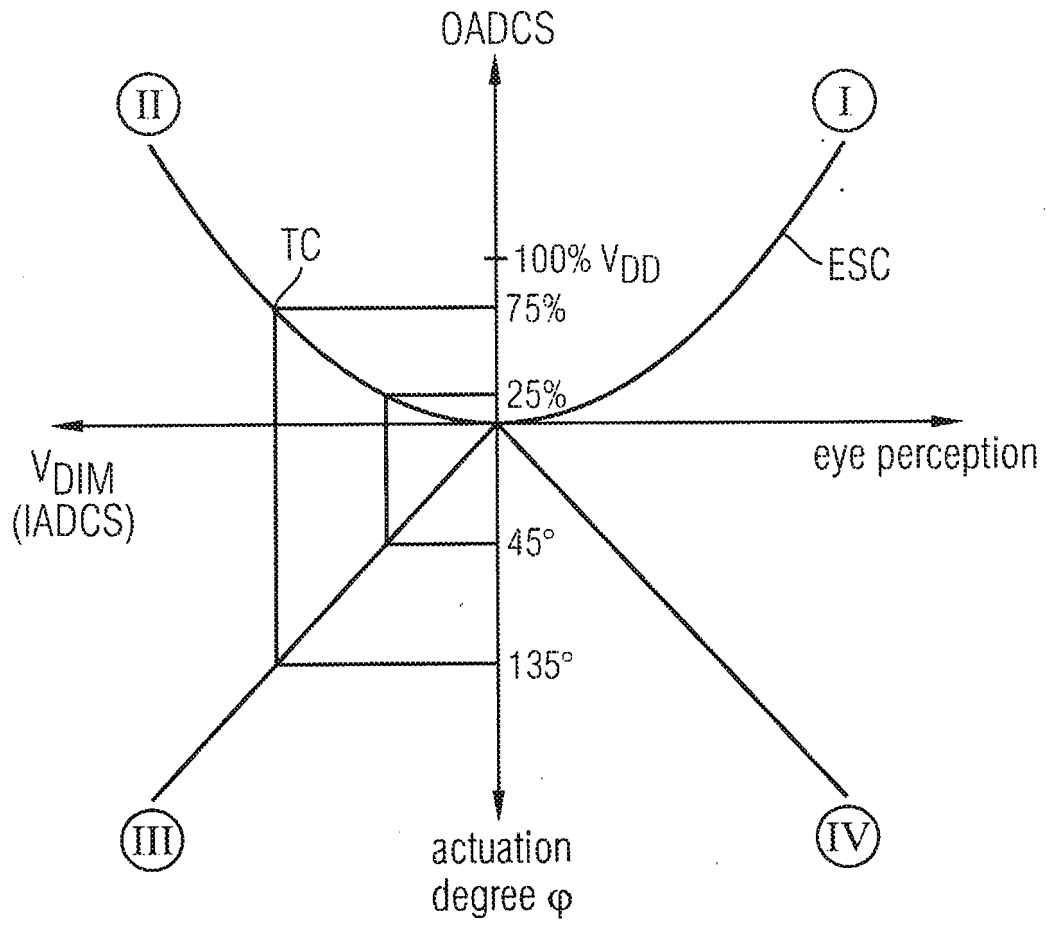


Fig. 4

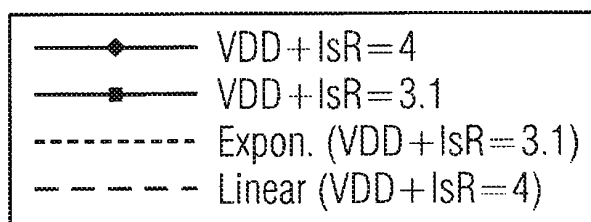
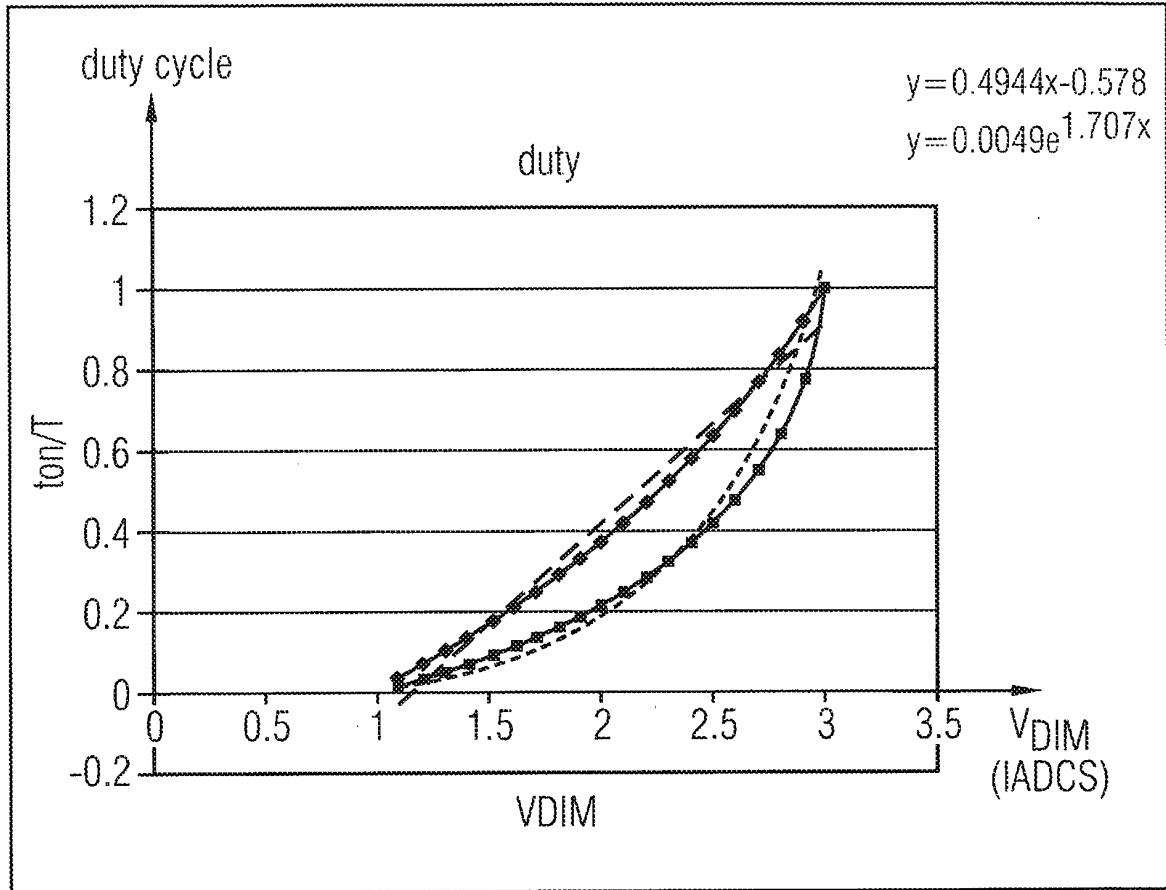


Fig. 5

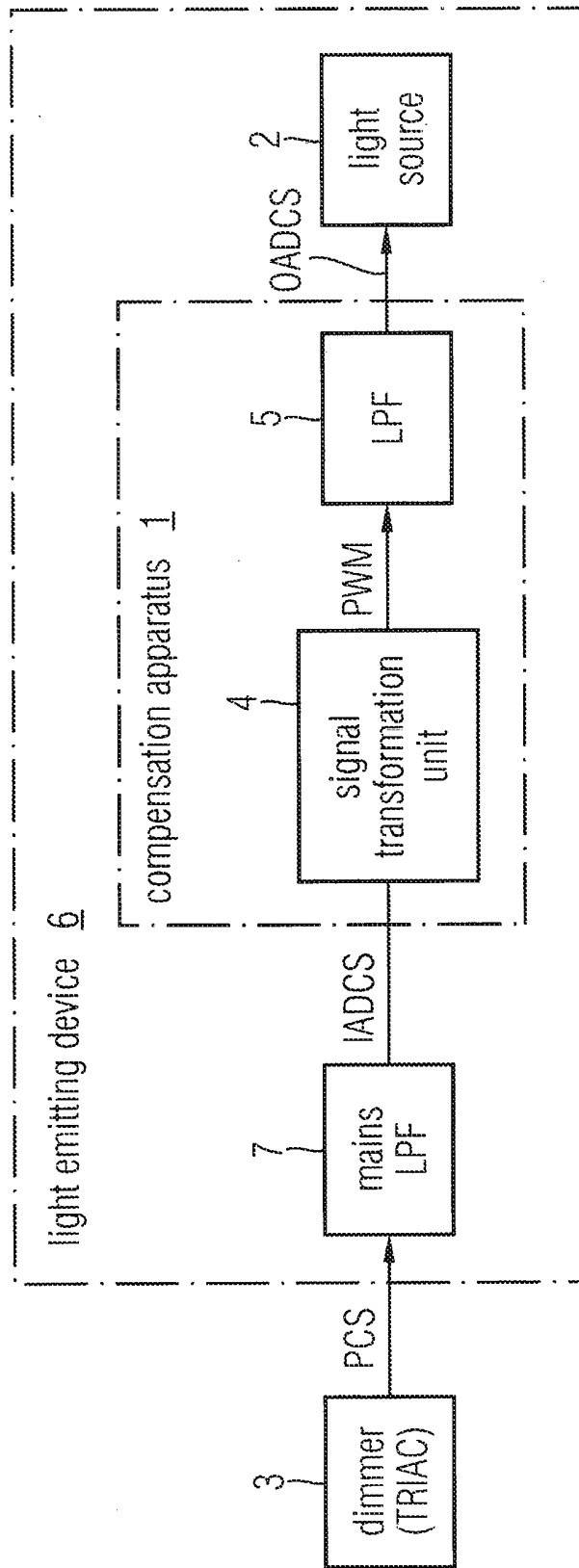


Fig. 6

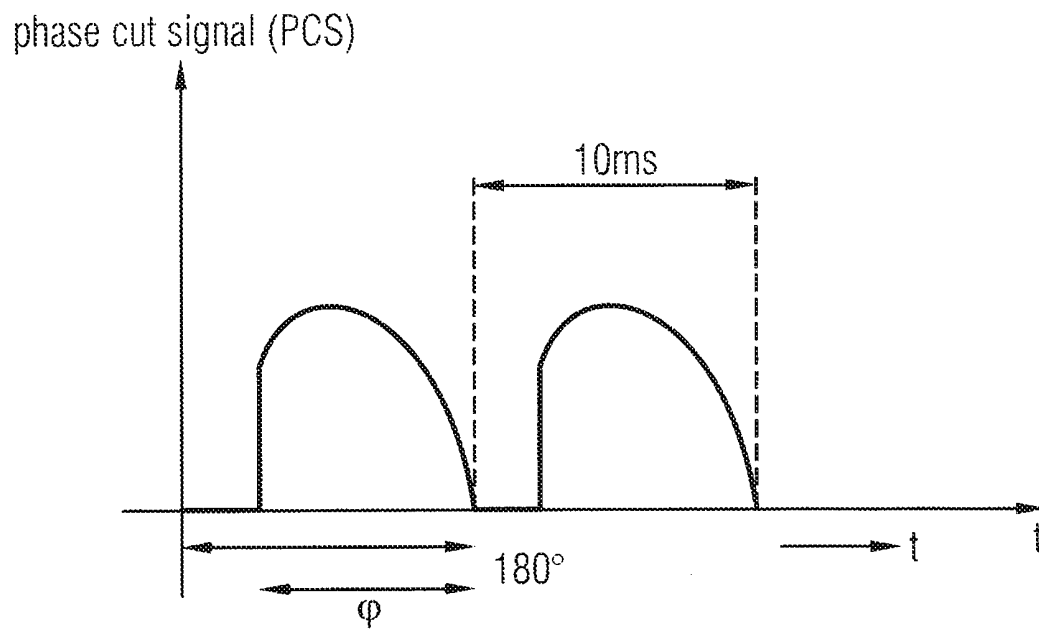


Fig. 7

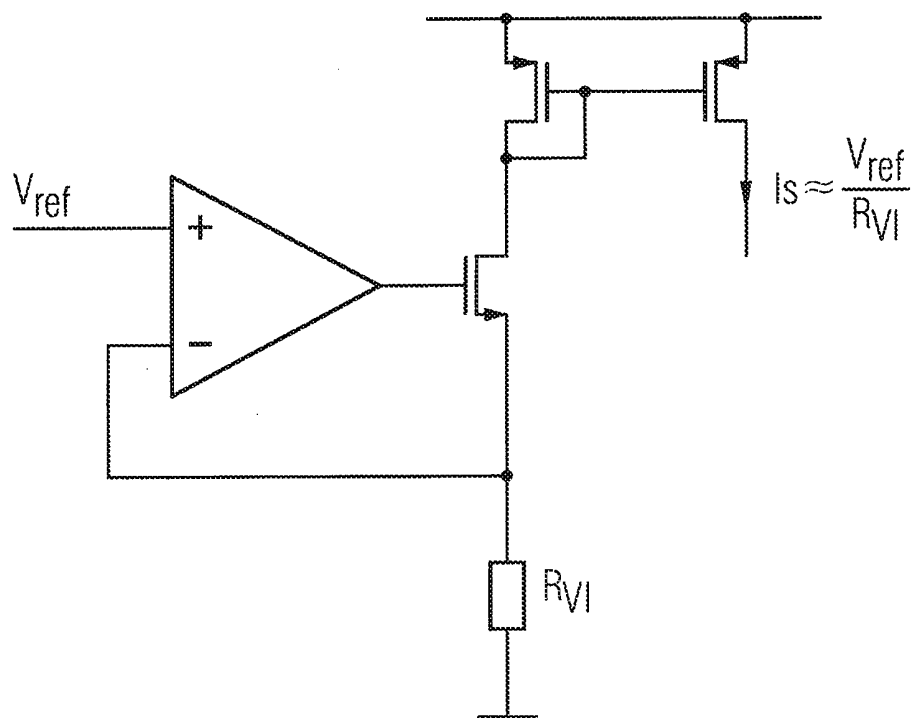


Fig. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE 102009013897 [0003]
- US 2010090618 A [0004]
- FR 2931616 [0005]
- WO 2009136328 A [0006]