

The present invention relates to a light dimming process and device for fluorescent lamps used in a rear lighting installation for a liquid crystal screen display apparatus.

5 The document FR-A-2584845 discloses a liquid crystal screen lit from the back by a fluorescent lamp. The supply to the lamp is interrupted during write periods and each commencement of interruption is synchronized with a minimum in the light emitted by the lamp, so
10 as to avoid flickering of the display surface.

Liquid crystal screens, in particular those involved in the colour display systems of aircraft and helicopter instrument panels, are lit from the rear so as to have a high luminance in order to be visible with
15 sufficient comfort within a very luminous environment. It must be possible to vary this luminance according to the various conditions of luminous environment, and it is generally necessary to control this luminance as a function of the day/night variations in this environment.
20 These variations require the luminous source to have a dynamic range greater than 1000/1, namely, in the case of fluorescent lamps, a brightness of the order of a few Cd/m² for the minimum luminance and about 15,000 Cd/m² for the maximum luminance.

25 It should be noted that the luminous source uses fluorescent lamps because of their excellent energy efficiency and their colorimetry which is well suited to liquid crystal screens.

In order to obtain optimal luminous efficiency
30 for these fluorescent lamps, the supply voltage applied between their two electrodes is a high alternating voltage, the amplitude of which is generally of the order of 300 to 500 volts, and the frequency of which is of the order of a few tens of kilohertz.

35 It is known to vary the luminance of a fluorescent lamp by varying the amplitude of its supply voltage, and consequently the intensity of the current passing through this lamp. The variation in luminance which this process makes it possible to obtain is only in a ratio of

less than 10/1, this being quite inadequate for the application mentioned above. Furthermore, since the starting voltage for fluorescent lamps depends on the temperature and, in particular, increases as the temperature decreases, this luminance control process does not allow operation within a wide temperature range, in particular for temperatures below 0 degrees celsius.

The range of variation in luminance can, in a known manner, be improved by frequency-modulating the AC supply voltage, and more specifically by using for the latter slots of variable frequency, for example from a few tens of hertz to a few tens of kilohertz. However, in this case, in order to fulfil the aforesaid operating conditions, it is necessary, for the lowest luminances, to work at frequencies below 15 kilohertz, but these frequencies may cause sound vibrations. Finally, at very low luminance level, beating appears through the stroboscope effect between the periodic illuminating of the lamps and the image refreshing, the frequency of which is of the order of 50 to 60 hertz. This is manifested by the scrolling over the screen of a horizontal bar of excess intensity, this being an unacceptable defect in a pilot display.

It is also known to vary the luminance of a fluorescent lamp by chopping the supply voltage by means of signals formed of slots whose width is adjustable. However, here again, problems appear from the stroboscope effect.

The invention aims to remedy these disadvantages. This is achieved by chopping the AC supply voltage of a fluorescent lamp for the rear lighting of a liquid crystal screen with a signal having slots of adjustable duration dependent on the desired luminous intensity, the front of the slots being synchronized with the "image synchronization" signal of the liquid crystal screen.

According to the invention, there is proposed a light dimming process for fluorescent lamp for the rear lighting of a liquid crystal screen, consisting in applying to the lamp an AC supply voltage chopped by

chopping signals formed of slots of adjustable duration dependent on the desired luminous intensity, characterized in that it consists in synchronizing the chopping signals with a signal corresponding to the image synchronization signal of the liquid crystal screen, frequency-
5 divided by an integer n greater than 0.

According to the invention, there is also proposed a light dimming device for fluorescent lamp for the rear lighting of a liquid crystal screen, including
10 a generator of chopping signals formed of periodic signals with slots, of fixed frequency and adjustable width, an AC voltage generator for supplying the fluorescent lamp and turn-off means controlled by the chopping signals so as to permit operation of the AC
15 voltage generator only for the duration of the slots, characterized in that, in order to implement the process according to either one of the preceding claims [sic], it includes means for synchronizing the chopping signals with a signal corresponding to the image synchronization
20 signal of the liquid crystal screen, frequency-divided by an integer n greater than 0.

The invention will be better understood and other characteristics will emerge from the description below and from the figures referring thereto which represent:

25 - Figure 1, an electrical diagram of a light dimming device according to the invention for a fluorescent lamp for the rear lighting of a liquid crystal screen;

- Figure 2, a timing chart explaining the operation of the device of Figure 1; and

30 - Figure 3, a partial electrical diagram of a variant embodiment of the device of Figure 1. Figure 1 shows a brightness control potentiometer 1 which receives its negative DC supply voltage on a terminal 2. One part of this DC voltage is tapped off by a slider 3 of the potentiometer 1, to constitute a DC voltage level with
35 amplitude adjustable by displacement of the slider 3, which, after levelling through an operational amplifier 4 (associated with a series resistor 5 and a negative-feedback resistor 6), is applied via a resistor 7 to the

inverting input 8 of a voltage comparator 9, itself supplied through a DC voltage $+V_o$, $-V_o$.

5 The non-inverting input 10 of the comparator is connected, via a resistor 11, to the output 12 of a sawtooth signal generator 13, whose signals are synchronized with the pulsed image synchronization signal of a liquid crystal screen; this pulsed signal is applied at 14 to the generator 13.

10 This generator 13 includes an operational amplifier 15 which is mounted as an integrator with the aid of a capacitor 17 which connects its input and its output and of a resistor 16 which connects its input to a terminal 18 to which a reference voltage V_2 is applied.

15 The fast sawtooth flyback is produced by a fast analog switch 19, of CMOS type, which is wired up in parallel to the capacitor 17 and which is controlled by image synchronization pulses shaped by a monostable flip-flop 20.

20 In Figure 2, which is a chart of amplitude (A)/time(t) curves, the (negative) image synchronization pulses 21 are represented on the upper curve A, whilst the output sawteeth 12 from the generator 13 are pictured at B. The adjustable DC level applied at 8 is drawn chain-dotted at 22.

25 Whilst the curves B and 22 are secant, negative and periodic voltage slots 23, of width L which can be adjusted by setting the slider 3, are generated at the output 24 of the comparator 9, the amplitude of these slots being equal to V_o .

30 The elements labelled 1 to 20 constitute a generator of periodic slots of fixed frequency but adjustable width, these slots being synchronized with the image synchronization pulses 21 of the liquid crystal screen, the rear lighting of which is to be effected.

35 The output 24 of the comparator 9 (slots 23) and the output 25 of the monostable flip-flop 20 (pulses 21) are applied to the two diodes 27, 22 respectively of an OR circuit 26; the output from the circuit 26 is coupled, through a resistor 29 followed by a reshaping amplifier

30, to the control input 31 of another analog switch 32. This switch 32 is open when a negative slot 23 or a negative pulse 21 is applied at 31, and it is closed otherwise. It constitutes a switch for turning off an oscillator 33 for supplying the fluorescent lamp 34 with high alternating voltage.

This oscillator 33 includes: a transformer with a main primary winding 35 with middle point 36, a feedback winding 40 with middle point 41 and a secondary winding 44, two NPN transistors 37, 38, a capacitor 39, three resistors 42, 43, 60 and a choke coil 48. The transistors 37, 38 have their emitters connected to earth, their collectors connected respectively to the two ends of the winding 35 and their bases connected respectively to the resistors 42, 43; these resistors are connected respectively to the two ends of the feedback winding 40. The capacitor 39 is arranged between the ends of the winding 35. The high-voltage secondary winding 44 of the transformer has a terminal connected directly to earth and another terminal connected, across a ballast capacitor 45, to an electrode 46 of the fluorescent lamp 34; the other electrode, 47, of the lamp is connected to earth.

The positive supply voltage $+V_1$ of the oscillator 33 is applied, via the choke coil 48, to the middle point 36 and, from there, across the resistor 60, to the middle point 41, whilst a negative DC turn-off voltage $-V_3$ is applied, when the switch 32 is closed, to the point 41, and across the resistor 60, to the point 36.

The operation of the circuit of Figure 1 is as follows:

When the slide 3 of the potentiometer 3 [sic] is in the top stop position (in Figure 1), the positive voltage applied to the terminal 8 is of maximum amplitude, greater than that of the sawteeth B, so that a DC voltage level of amplitude equal to $-V_0$, is applied at 24.

The voltage applied to the control input 31 of the switch 32 is then a DC level, so that the switch 32

remains permanently open and so that the oscillator 33 operates without interruption, and supplies the fluorescent lamp 34 at its maximum luminance.

When, from this top stop position, the slider is
5 displaced gradually downwards (in the direction of earth), the voltage level 22 (Figure 2) decreases in amplitude and cuts the sawtooth curve B, which generates the slots 23, of a width L which decreases gradually as the slider 3 approaches earth, and whose leading edge is
10 synchronized with that of the pulses 21. The oscillator 33 then operates only for the duration of these slots 23 (curve D of Figure 2) since, outside the latter, the switch 32 is closed and therefore the voltage -V3 turns off the oscillator 33.

15 The luminous intensity provided by the lamp 34 is then proportional to the width L of the slots 23, which depends on the position of the slider 3.

When the slider 3 reaches the bottom stop (earth side), there is no longer any signal appearing at 24,
20 but, by virtue of the OR circuit 28, the pulses 21 are nevertheless applied to the control terminal 31, thus causing the oscillator 33 to operate for the duration of the image synchronization pulses 21: thus, a non-zero minimum brightness is advantageously obtained for the
25 lamp 34.

The circuit according to Figure 3 is a representation of another device according to the invention, in the part thereof where it differs from that according to Figure 1; this circuit includes a series resistor 49, or
30 "stub resistor", which is inserted between the electrode 47 of the lamp 34 and earth. The voltage across the terminals of this stub resistor 49 is applied, via a rectifier 50 and a series resistor 51, to a first input 52 of a differential amplifier 53. The other input 55 of
35 this differential amplifier 53 receives, by way of a reference voltage V4 and of an adjustable resistor 54, a DC voltage of adjustable value.

The output of the differential amplifier 53 is connected to the control input 56 of a voltage regulator

57, which is inserted between the supply terminal +V1 and the choke coil 48 and which is able to vary the DC voltage on its output 58 as a function of the control voltage which it receives at 56.

5 The part of the device of Figure 3, where the labels 49 to 57 appear, constitutes a feedback control loop whose role is to control the current in the resistor 49, and hence in the lamp 34, by the value given by the reference voltage applied to the input 55, which value
10 depends on that of the adjusting resistor 54; thus it is possible to optimize the value of the supply voltage of the lamp 34 as a function of its operating point, while then minimizing the power dissipated and circumventing variations in temperature.

15 Furthermore, the circuit of Figure 3 allows the starting of the lamp 34 at low brightness or at very low ambient temperature.

 It is appropriate in this regard to recall that the voltage for starting fluorescent lamps depends on the
20 temperature of the electrodes and on the enclosure which contains the mercury vapour. At low brightness, the mean current which passes through the lamp is very low and does not heat up the lamp. The starting voltage is then higher than in the case in which the lamp is very bright.
25 This starting voltage then also rises as the ambient temperature diminishes.

 In the event of non-starting, due to too low a brightness or too low an ambient temperature, no voltage is applied to the terminal 52 of the differential amplifier 53, so that the maximum control voltage of the
30 regulator 57 is applied at 53, thus increasing the effective supply voltage to the oscillator 33 to above its starting voltage under these unfavourable conditions, this assuming of course that the voltage +V1 is of
35 sufficient amplitude.

 The circuit of Figure 3 makes it possible to effect a pairing up of low-brightness lamps.

 In the case of lighting with two or more fluorescent lamps, these lamps have to be paired up for the low

brightness levels so as to obtain identical starting voltages for these lamps, otherwise one of the lamps might light and the other not; to do this, each lamp has its own circuit according to Figure 3. This pairing is achieved by setting the resistors 54 of each circuit so that all the lamps start up together for the same operating conditions. For this purpose, it is also possible to adjust the stub resistors 49, but this solution is not as good, since it might increase the losses.

It was mentioned above that the minimum luminance was obtained by chopping, or modulating, the alternating voltage of the oscillator 33 using slots whose duration corresponds to the width of the image synchronization pulses 21. Now, these pulses 21 have a width of the order of 50 microseconds. In theory, to obtain, as required, a variation in the luminance of the fluorescent tube 34 in a ratio of 1 to 1000, a variation in the width L of the pulses 23 would be necessary ranging from 50 microseconds to 1000 times more, that is to say 50 milliseconds. Now, chopping at 50 milliseconds corresponds to a frequency of 20 hertz, and this would introduce a visible flicker in the image provided by the liquid crystal screen so that in fact, following this theory through purely and simply, the device according to the invention could not operate under the required conditions (brightness ratio of 1000/1).

In reality, such is not the case since, when the lamp 34 is allowed to operate only for 50 microseconds, it does not have time to heat up, the starting operation not sufficing by itself to raise the temperature of the lamp. Its luminous efficiency when cold is then a third of that corresponding to continuous or near-continuous operation, that is to say when hot, so that the ratio of 1 to 1000 in luminance is finally obtained on passing, for the width L of the pulses for chopping the sinusoidal voltage of the oscillator 33, from 50 microseconds to about fifteen milliseconds, this corresponding to a chopping frequency appreciably greater than those which cause the appearance of a flicker phenomenon.

The invention is not limited to the illustrative embodiments just described. Thus, for example, in the context of automatic feedback control by the luminous environment, the brightness control potentiometer, 1, can
5 be replaced by a photodetector which provides a voltage proportional to the desired luminance. In the above example, the front of each slot 23 for chopping the sinusoidal voltage of the oscillator 33 is synchronized with the image synchronization signal of the liquid
10 crystal screen. In order to extend the dynamic range of operation of the device, it is also possible to synchronize this slot with the image synchronization signal frequency-divided by an integer greater than 1. Clearly, this is only possible if the frequency of this signal,
15 when divided by this number, is not low enough to introduce a flicker phenomenon. It is also possible, when several fluorescent lamps are necessary, to use just a single switch 32, provided that a resistor is inserted into the connection between this switch and the point 41
20 of each oscillator specific to each of these lamps.

CLAIMS

1. Light dimming process for fluorescent lamp (34) for the rear lighting of a liquid crystal screen, consisting in applying to the lamp (34) an AC supply voltage
5 chopped by chopping signals formed of slots (23) of adjustable duration (L) dependent on the desired luminous intensity, characterized in that it consists in synchronizing the chopping signals (23) with a signal corresponding to the image synchronization signal (21) of
10 the liquid crystal screen, frequency-divided by an integer n greater than 0.
2. Light dimming process according to Claim 1, characterized in that minimum luminance of the lamp is obtained by using the pulses of the image synchronization
15 signal (21) of the liquid crystal screen as chopping signals.
3. Light dimming device for fluorescent lamp (34) for the rear lighting of a liquid crystal screen, including a generator (1 to 20) of chopping signals formed of
20 periodic signals (23) with slots, of fixed frequency and adjustable width (L), an AC voltage generator (33) for supplying the fluorescent lamp (34) and turn-off means (32) controlled by the chopping signals (23) so as to permit operation of the AC voltage generator (33) only
25 for the duration of the slots (23), characterized in that, in order to implement the process according to either one of the preceding claims, it includes means (13) for synchronizing the chopping signals with a signal corresponding to the image synchronization signal (21) of the liquid crystal screen, frequency-divided
30 by an integer n greater than 0.
4. Light dimming device according to Claim 3, characterized in that it uses the pulses of the image synchronization signal (21) of the liquid crystal screen
35 as chopping signals so as thereby to obtain a minimum luminance value for the fluorescent lamp (34).

