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(54) Operation voltage controller and method for controlling an operation voltage controller

(57) The present invention relates to an operation voltage controller for a signal powered field device having a display, comprising a power supply for transforming the signal into a high voltage output and a low voltage output, a basic device functions means being supplied by the low voltage output such that an operation voltage is applied at the basic device functions means, and a back lighting means for back lighting a display of the signal powered field device.

The present invention relates also to a method for controlling an operation voltage controller of a signal powered field device having a display, wherein the operation voltage controller comprises at least a basic device functions means, the method comprising the following steps: transforming the signal into a high voltage output and a low voltage output, supplying the basic device functions means with the low voltage output such that an operation voltage is applied at the basic device functions means, and back lighting a display of the signal powered field device.

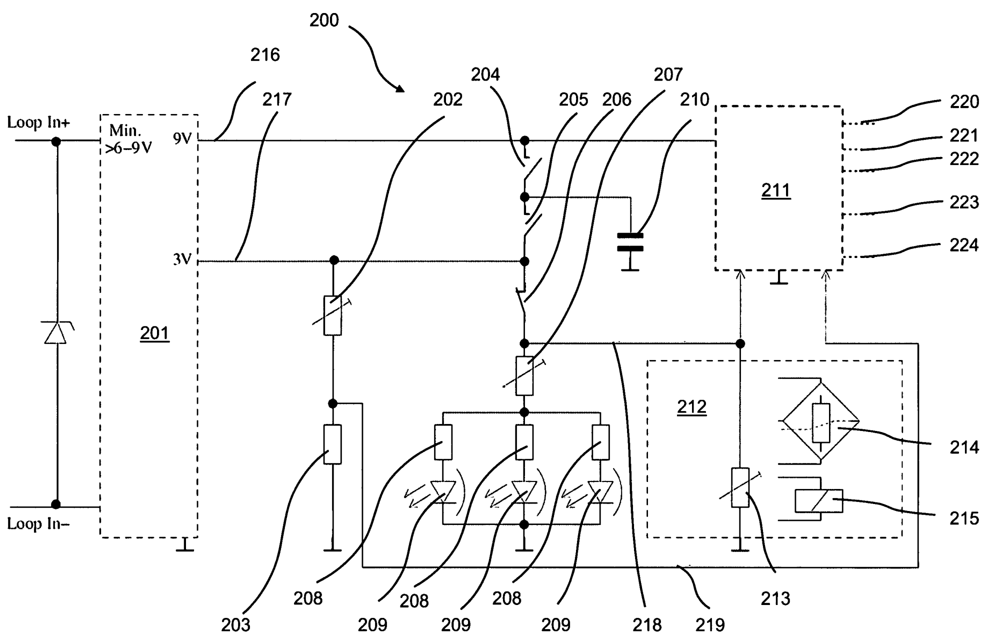

Fig. 10

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Description

[0001] The present invention relates to an operation voltage controller for a signal powered device having a display and a method for controlling an operation voltage controller of a signal powered device having a display in accordance with the preamble of claim 1 and claim 18, respectively.

[0002] There are so called signal powered devices. Such devices are operated at locations where it is not desired to have a separate power supply, for instance for safety reasons, because at these locations sparks and heat is to be avoided such as a gas and/or fuel pipe.

[0003] Such devices are normally powered by a loop signal and/or a transmission signal, for instance an analogue 4-20 mA loop signal or a bus signal, like the Fieldbus H1 or the Profibus PA. For example, the loop signal can be an analogue 4-20 mA output signal provided for instance to an electro pneumatic actuator position controller for a pneumatic valve actuator, as SRD991, SRD960 or any competitive device. The loop signal can be an analogue 4-20 mA input signal from, for example, a transmitter device, which converts any physical measured value to a 4-20mA loop signal. The transmission signal can be a 2-wire bus that provides the communication signal to transfer process variables and other information and the power distribution of the field device at the same time.

[0004] Devices, which are powered by a signal have in most cases a limited power budget and need a special power management to drive their own electronic. In addition energy has to be provided for any special tasks of the device, for instance if the device is an output device for a process control system, which for instance has to drive an electro pneumatic transducer or converter (current or voltage to pneumatic flow or pneumatic pressure), and/or other output actuators and/or to drive in addition sensors e. g. to measure pressure and/or position of the actuator and/or sensors for additional diagnostic measurements. For instance, if the device is an input device for a process control system, the device has to drive in addition to its own basic operating electronic the sensor for the physical input, diagnostic sensors, a local display etc. A bus device can be used as input or output device or both for a process system. In most cases it is necessary, to have on such devices also a local display in addition to the communication, or if communication is not featured or not available, to operate the device by configuring the features, calibrating physical inputs or calibrating actuators to any process needs or it is to read measured values. Because of the lack on power on such signal powered devices, back lightening of the local LCD display has never been provided and/or envisaged by the skilled person.

[0005] As stated the signal powered devices normally do have a display for providing the operator with information needed, for instance for services such as configuration, operation and/or diagnostics services. These displays have never been equipped with a back light means due to the limited power available for the signal powered devices. However the back light means would be advantageous to have, especially for signal powered devices at dark locations where the display cannot read without having a back light means. It is clear, that external lighting means cannot easily be used for safety reasons.

[0006] Accordingly it is an object of the present invention to provide a signal powered device having a display with an improved power management being able to provide a back light means.

[0007] This object of the invention is achieved by a signal powered device in accordance with the features of claim 1. Preferred embodiments are disclosed in the dependent claims.

[0008] The object of the invention is also achieved by method in accordance with the features of claim 18. Preferred embodiments are disclosed in the dependent claims.

[0009] In accordance with the invention there is provided an operation voltage controller for a signal powered field device having a display, comprising a power supply for transforming the signal into a high voltage output and a low voltage output, and a basic device functions means being supplied by the low voltage output such that an operation voltage is applied at the basic device functions means, characterised by a back lighting means for back lighting a display of the signal powered field device.

[0010] In accordance with the invention a strategy has been developed, to deal with the low amount of available energy, such that the operation of a back light with some power reserve becomes possible. According to the invention the highest priority is given for applying enough power to the basic device functions for operating the device. The power consumption of the basic device functions varies over time and depends on the operation tasks.

[0011] The system signal, for example the 4-20mA signal, provides more or less power from the system to the signal powered device. If for instance the signal current of a 4-20mA signal is 4mA, and if then the terminal input voltage of the signal powered device is for instance 10V, the power consumed by the device is 40mW. For a 20mA signal current at the same voltage of 10V, the power consumption is 200mW.

[0012] In the worst cases the basic function of the device has to be operable at least at 3.6mA, even if the basic function can have its highest power consumption. The power consumption of the basic functions mostly vary in time cycles of approximately 1ms to 1s, especially, if micro controllers are used in the electronic design, which normally have an interrupt controlled software system.

[0013] The power consumption peaks and consumption breaks vary sometimes from 10% to 200% of the minimum input power (36mW). Without an efficient energy buffer the operation above 100% peak power would not be possible, even not for a short time. The energy buffer takes the loop signal power that is more or less not used from the basic function.

[0014] When the buffer is full the unused power must be eliminated. The usual way is to sink the current into a zener diode or to sink the current with a transistor or any variable resistor element. In accordance with the invention most of this energy, which would be otherwise sunk, is stored and used to drive a minimum of one back light LED, or some back light LEDs in series or parallel with this unused current. With other words, the LEDs are used to sink excess energy and also used to provide back light illumination for the display of the signal powered device.

[0015] Every load variation of the basic function leads to a variation of back light current. The fast load variation cycles are normally not recognized from the user eyes, when he is viewing the LCD display graphics. Therefore the operator will not recognize a variation of the back light level but see a constantly back lighted display.

[0016] In accordance with the invention the back light means (for instance LEDs) can be operated by the operation voltage as follows: If there are high operation voltage changes due to load changes of the basic device functions, the back light current will sink the excess energy and improves the stability of the operating voltage. Further excess energy can be sunk by directing some current through a load (For instance if maximum energy is provided to the back light means). In accordance with this embodiment changes of the back light current will be smoothed.

[0017] In accordance with the invention the back light means (for instance LEDs) can be coupled to the buffer. If the energy buffer is charged sufficiently, the unused current can be directed through the back light means. Further excess energy can be sunk by directing some current through a load (For instance if maximum energy is provided to the back light means). In accordance with this embodiment changes of the back light current will be smoothed.

[0018] In accordance with the invention the stability of the power supply can also be achieved by a voltage controller that charges and discharges a buffer. Details of this solution are disclosed for instance in the document EP 1 22 427 A1 having the title "Load Voltage Control for a Field Device", the disclosure thereof is incorporated into the present specification by way of reference.

[0019] The buffer can comprise for instance a capacitor or a gold capacitor with a very high capacitance, as described for instance in EP 1 22 427 A1. In accordance with one embodiment the back light means (for instance the LEDs) can be switched on whenever the operating power as used by the signal powered device is less than available input power from the signal and/or the energy buffer can provide sufficient energy.

[0020] Preferably, a threshold can be provided for the operation of the back light means, such that the back light means will be switched on only if sufficient excess energy is available from the signal and/or the buffer.

[0021] In accordance with the invention the buffer can comprise an accumulator. Depending on the exact design, the charge time and discharge time of the buffer can be increased. Preferably, a threshold can be provided for the operation of the back light means, such that the back light means will be switched on only if sufficient excess energy is available from the signal and/or the buffer.

[0022] In accordance with the invention the buffer can comprise alternatively and/or in addition a battery. One advantage of providing a battery is that power for the back light means will be available from the very beginning of operation. One disadvantage is that the battery has to be exchanged from time to time, if this advantage is needed anymore.

[0023] To save additional battery or accumulator power for the above mentioned embodiments comprising a buffer with a battery and/or an accumulator, it can be an improvement to switch off the back light means after the operator has used the display and to switch the back light means on again, if the operator starts using the local display of the device (configuration, maintenance, viewing measure values etc.). The switch off function can be provided with a time delay, i.e. the back light means will be switched after a specific time of not operating the device buttons, or can be provided by a menu item. The switch on function can be provided immediately after any button has been pushed by the operator.

[0024] According to the invention the back lighting means can comprise at least one light emitting diode, preferably a plurality of light emitting diodes and more preferred three light emitting diodes.

[0025] According to the invention the back lighting means can comprise a back light current adjusting means for adjusting the back light current depending on the operation voltage applied at the basic device functions means. Preferably the back light current can be decreased if the operation voltage is below a preset level and can be increased if the operation voltage exceeds the preset level.

[0026] According to the invention the operation voltage controller can further comprise a buffer designed and adapted to be charged by connecting the buffer to the high voltage output and designed and adapted to be discharged by connecting the buffer to the low voltage output, wherein preferably the back lighting means comprises a back light current adjusting means for adjusting the back light current depending on the charge level of the buffer. Preferably the back light current can be decreased if the charge level of the buffer is below a preset level, preferably a high limit of charge, and can be increased, if the charge level of the buffer exceeds the preset level. In addition and/or alternatively the buffer can be charged, if the output voltage exceeds a set point value, and the buffer can be discharged, if the output voltage does not exceed a set point value. In addition and/or alternatively the buffer can comprise a capacitor, an accumulator and/or a battery.

[0027] According to the invention the operation voltage controller can further comprise a test load for sinking excess energy by applying a test load voltage to the test load such that a test load current is flowing through the test load. Preferably the test load current can be increased, if the back light current is at its maximum, and the test load current can be decreased, if the back light current is below its maximum. In addition and/or alternatively the test load current can be increased, if the buffer voltage exceeds a high limit, and the test load current can be decreased, if buffer voltage does not exceed the high limit.

[0028] According to the invention the operation voltage controller can further comprise a power management controller for controlling the charge level of the buffer, the back light current and/or the test load current. Preferably the power management controller can be supplied with energy by the high voltage output and/or the low voltage output.

[0029] According to the invention the back lighting means can comprise a reflector. Preferably the reflector can be designed and adapted for reflecting light emitted from a light source to the display of the signal powered field device and for providing a support for the display such that the display is located in a specific distance above a printed circuit board onto which the light source is mounted.

[0030] This embodiment has the advantage that the reflector serves a double function. Besides guiding the light the mounting of the display onto the printed circuit board in a specific desired distance will be much simplified, as explained in the detailed description of the preferred embodiments in further detail.

[0031] According to the invention there is also provided a signal powered field device comprising an operation voltage controller in accordance with the invention. Preferably the signal powered field device can further comprise an explosion proof and/or flame proof and/or pressure tight housing which preferably can comprise a window for the display. Preferably the operation voltage controller can comprise at least one switch, preferably a push button, mounted on a printed circuit board and the housing can comprise a corresponding number of actuating means for actuating the switches or push buttons through the wall of the housing.

[0032] According to the invention there is also provided a method for controlling an operation voltage controller of a signal powered field device having a display, wherein the operation voltage controller comprises at least a basic device functions means, the method comprising the following steps:

transforming the signal into a high voltage output and a low voltage output,

supplying the basic device functions means with the low voltage output such that an operation voltage is applied at the basic device functions means, and

back lighting a display of the signal powered field device.

[0033] According to the invention the back lighting can be made by means of at least one light emitting diode, preferably by means of a plurality of light emitting diodes and more preferred by means of three light emitting diodes.

[0034] According to the invention a back light current can be adjusted depending on the operation voltage applied at the basic device functions means. Preferably the back light current can be decreased, if the operation voltage is below a preset level, and increased, if the operation voltage exceeds the preset level.

[0035] According to the invention the operation voltage controller can further comprise a buffer, wherein the buffer can be charged by connecting the buffer to the high voltage output and discharged by connecting the buffer to the low voltage output, wherein the back lighting means comprises a back light current adjusting means for adjusting the back light current depending on the charge level of the buffer. Preferably the back light current can be decreased, if the charge level of the buffer is below a preset level, which is preferably a high limit of charge, and increased, if the charge level of the buffer exceeds the preset level. In addition and/or alternatively the buffer can be charged, if the output voltage exceeds a set point value, and the buffer can be discharged, if the output voltage does not exceed a set point value.

[0036] According to the invention the method can further comprise the step of sinking excess energy by applying a test load voltage to a test load of the operation voltage controller such that a test load current is flowing through the test load. Preferably the test load current can be increased, if the back light current is at its maximum, and the test load current can be decreased, if the back light current is below its maximum. In addition and/or alternatively the test load current can be increased, if the buffer voltage exceeds a high limit, and the test load current can be decreased, if the buffer voltage does not exceed the high limit.

[0037] According to the invention the method can further comprise the step of switching the basic device functions on, if the test load voltage exceeds an operation start limit.

[0038] In accordance with the invention the method can use an operation voltage controller and/or a signal powered field device in accordance with the invention.

[0039] The LEDs, if used for the back light illumination, can be very sensitive, e.g. 1000-5000 mlum/20mA and/or can have a radiation angle of approx. 120° (depending on the design). Preferably the LEDs are located at optimal locations beneath the display, such that the light is equalized over the backside area of the display (for instance an LCD). There may be provided a diffusing film and a polarization filter. The light reflector of the display at the bottom side of the display (for instance the bottom glass of the LCD) needs to be transparent for the back light, normally 10% transparent and 90% reflecting day light. To improve the back light equalization a diffusing film, a polarization filter and/or a light reflector (preferably having a parabolic profile around the LEDs) can be used. The equalization of light intensity is more important than the intensity itself, in order to provide a better display such that smaller pixel graphics on the display can be read by the operator.

[0040] The invention will be explained in further detail with reference to the drawings, wherein the following reference numbers are used:

1	display and printed circuit board assembly
10	printed circuit board
11	push button
12	light emitting device (LED)
20	reflector
21	edge
22	leg
23	end wall
24	side wall
25	ridge wall
26	extension
27	snap fit
28	pin
30	display
100	cycle of method for controlling an operation voltage controller
101	test: buffer beneath low limit of charge?
102	operation: switch basic device functions off (open switch 206)
103	test: low voltage output exceeds a set point value?
104	operation: charge buffer (close switch 204; open switch 205)
105	operation: discharge buffer (close switch 205, open switch 204)
106	test: buffer exceeds high limit of charge?
107	operation: increase test load current
108	operation: decrease test load current
109	test: test load voltage exceeds operation start limit?
110	operation: switch basic device functions on (close switch 206)
111	test: basic device functions on? (or: switch 206 closed?)
112	test: buffer voltage exceeds high limit?
113	operation: increase back light current
114	operation: decrease back light current
115	test: back light current at maximum?
116	operation: increase test load current
117	operation: decrease test load current
120	node
121	node
122	node
123	node
123A	node
124	node
125	node
200	operation voltage controller
201	power supply
202	test load current adjusting means
203	test load
204	switch (for charging buffer 210)
205	switch (for discharging buffer 210)
206	switch (for switching back lighting means and basic device functions means 212)
207	back light current adjusting means
208	resistor
209	light emitting device (LED, for back lighting display 30)
210	buffer
211	power management controller
212	basic device functions
213	energy consumption means
214	sensors
215	actuators
216	high voltage output
217	low voltage output
218	operation voltage
219	test load voltage
220	charge buffer signal
221	discharge buffer signal
222	basic device functions on/off signal
223	increase or decrease back light current signal
224	increase or decrease test load current signal

[0041] Preferred embodiments of the invention are shown in the attached drawings:

Fig. 1	is a schematic side view of a display and printed circuit board assembly in accordance with an embodiment of the invention.
Fig. 2	is a exploded side view of the display and printed circuit board assembly of Fig. 1.
Fig. 3	is a front view of the display and printed circuit board assembly of Fig. 1.
Fig. 4	is a top view of the reflector of the display and printed circuit board assembly of Fig. 1.
Fig. 5	is a bottom view of the reflector of Fig. 4.
Fig. 6	is a cross section view of the reflector of Fig. 4 along lines VI-VI of Fig. 5.
Fig. 7	is a cross section view of the reflector of Fig. 4 along lines VII-VII of Fig. 5.
Fig. 8	is a perspective top side view of the reflector of Fig. 4.
Fig. 9	is a perspective bottom side view of the reflector of Fig. 4.

Fig. 10 is a circuit diagram of an operation voltage controller in accordance with the invention.

Fig. 11 is a flow chart of the operation voltage controller method in accordance with the invention.

[0042] Figs. 1 to 3 show a display and printed circuit board assembly 1 in accordance with the invention. On a printed circuit board 10 there is a plurality of push buttons 11 and the display 30.

[0043] The display and printed circuit board assembly 1 of this embodiment is adapted such that it can be mounted into a explosion proof housing. Therefore the display 30 is located a specific distance above the printed circuit board 10 such that the display 30 can be located just beneath a window whereas the push buttons 11 can be located beneath a thick walled housing with actuators extending through the wall in a manner known to the skilled person. Accordingly the display 30 has long pins 31 and 32 to be connected in respective holes of the printed circuit board 10. Normally the pins 31 and 32 are fixed to the holes in the printed circuit board 10 by soldering. However, it is clear that any equivalent means of fixing the pins 31, 32 to the printed circuit board 10 can be used.

[0044] Between the display 30 and the printed circuit board 10 there is arranged a diffusing film 40 and a reflector 20 as it can best be seen from Fig. 2. Optionally a polarization film (not shown) can be located between the display and the diffusing film. Other arrangements known to the skilled person are possible.

[0045] The reflector 20 defines the distance of the display 30 from the printed circuit board 10. The reflector 30 has therefore the double function of providing reflecting walls for reflecting light emitted from light emitting diodes (LEDs) 12 to the display 30 and of ensuring than the display 30 is mounted a specific distance above the printed circuit board 10.

[0046] This is advantageous because in the prior art without having a reflector, fitting the display 30 the specific distance above the printed circuit board has been very difficult and time-consuming. Often a tool has been made by the person fitting the display in order to ensure that the display is located the required specific distance above the printed circuit board. This tool was placed between the display and the printed circuit board before fixing the pins to the printed circuit board. This prior art display and printed circuit board assembly has also the disadvantage that the display may unintentionally be dislocated, for instance by mounting the assembly into its housing, because the pins could have been bent such that the display 30 could have been dislocated to one side and closer to the printed circuit board. In that case an operator may not be able to read the display.

[0047] The reflector 20 will be described in more detail in connection with Figs. 4 to 9. The reflector 20 comprises three openings for LED's 12 (see for instance Fig. 1) mounted at the printed circuit board 10.

[0048] There are parabolic walls at each side of each compartment. As it best can seen from Fig. 4 there are two end walls 23 each defining one wall of the respective outermost compartment. The side walls 24 define opposing walls of all compartments. Between two adjacent compartments, there are respective ridges, each having two ridge walls 25 defining respective side walls of these adjacent compartments.

[0049] Any other walls providing a uniform illumination of the display to be back lighted are possible.

[0050] On the top of the reflector 20 there are means for housing the display and the diffusing film to be placed between the reflector and the display 30. This means as illustrated comprise an extension 26 having at its end a snap fit 27, although other structures known to the skilled person may also be suitable for this purpose.

[0051] As it best can seen in Fig. 7 there are two edges 21 having an inwardly protruding protrusion beneath which the display 30 can be located with its edges.

[0052] The reflector 20 also comprises four legs 22 at the bottom. Two of the legs 22 have a pin 28 to be inserted into a respective hole provided in the printed circuit board 10.

[0053] Fig. 10 is a circuit diagram of an operation voltage controller in accordance with a preferred embodiment of the invention which is generally indicated with the reference number 200.

[0054] This operation voltage controller may be used in a signal powered field device getting its operating power from a signal like a 4-20mA loop signal or getting its operating power from a bus signal like the Fieldbus H1 or the Profibus PA, for example. These field devices have in addition a display to be used for configuration, operation and/or diagnostic purposes on site. For such local operations normally at least one push button is available. Without having a push button information like measurement values and messages may be displayed.

[0055] The power supply 201 gets its energy from the loop signal as schematically indicated at the left hand side of the power supply 201 and indicated by Loop In+ and Loop In-.

[0056] The power supply 201 of this embodiment or any other embodiment of the invention can be embodied with a charged pump for dividing an input voltage and multiplying the output current. Such a charged pump is known to the skilled person from the international application published as WO 98/35430, the disclosure thereof is incorporated into the present specification by way of reference. Such a charged pump is able to move the charge from one voltage level to another voltage level and thus increase the output current while decreasing the output voltage. For instance the charged pump can comprise a current conversion circuit having multiple voltage levels with CMOS gates that switch the output capacitors so as to be coupled to the input of another level to move the charge from one voltage level to another voltage level and thus increase the output current while decreasing the output voltage.

[0057] The loop signal can be a 4-20mA output signal for instance of an electro-pneumatic actuator position controller for pneumatic valve actuators, such as SRD 991, SRD 960 (both are available at the owner of the present invention) or any other competitive device. The loop signal can also be a 4-20mA input signal from for instance a transmitter device, which converts any physically measured value to a 4-20mA loop signal. As stated the energy for the power supply 201 can also be obtained from a transmission signal being a two wire bus that provides the communication signal to transfer process variables and other information and the power distributor of the field device at the same time.

[0058] The power management controller 211 gets the high voltage output 216 of the power supply 201 which is for instance, as shown in Fig. 10, 9V. The power supply 201 also provides a low voltage output 217 which is for instance, as shown in Fig. 10, 3V.

[0059] Between the high voltage output 216 and the low voltage output 217 there are two switches 204, 205 and a buffer 210. The switch 204 is for charging the buffer 210 by connecting the buffer 210 with the high voltage output 216. The switch 205 is for discharging the buffer 210 by connecting the buffer 210 with the low voltage output 217.

[0060] For sinking excess energy there is a test load 203, for instance a resistor which will transform the excess energy into heat. The test load 203 is connected to the low voltage output 217 via an adjusting means 202 provided for increasing or decreasing the test load current 202.

[0061] There are means for back lighting a display as shown for instance in Figs. 1 to 3 and a black box generally depicting the basic device functions means 212. The basic device function means 212 is depicted as black box having energy consumption means 213, schematically depicted sensors 214 and schematically depicted actuators 215. The basic device functions means 212 are known to the skilled person and are not described in further detail here.

[0062] The means for back lighting the display comprise a plurality of LEDs 209. In the depicted embodiment the LEDs are connected in parallel to each other, each having a resistor 208 connected in series thereto. In addition there is an adjusting means 207 provided for increasing or decreasing the back light current for all LEDs. The adjusting means 207 is connected in series to the parallel connection of the LEDs 209 and its respective resistors 208.

[0063] The means for back lighting the display and the basic device functions means 212 are connected in parallel to each other. There is a switch 206 for connecting the back lighting means and the basic device functions means 212 to the low voltage output 217. Switch 206 is therefore for switching the basic device functions means 212 on or off. Since there is a single switch 206, it is clear from Fig. 10, that the back lighting means will only be switched on, if the basic device functions means 212 are switched on and vice versa.

[0064] There is a resulting operation voltage 218 providing energy for operating the back lighting means and the basic device functions means 212.

[0065] In addition there is a power management controller 211 for controlling the power provided to the various means of the circuit.

[0066] The power management controller 211 comprises at least two inputs for observing operation parameters. In the embodiment shown, the power management controller 211 comprises two inputs. The operation voltage 218 is connected to one input for measuring the operation voltage 218. The test load voltage 219 is also observed by the power management controller 211 and connected to its other input.

[0067] The power management controller 211 has at least five outputs controlling the power provided to the various means of the circuit.

[0068] There is the charge buffer signal 220 which is used to close switch 204 if the buffer 210 is to be charged. There is also a discharge buffer signal 221 which is used to close switch 205 if the buffer 210 is to be discharged. It is clear that either switch 204 or 205 is closed. In principal it is also possible that both switches 204 and 205 are open. However in the preferred embodiment the two switches 204 and 205 are closed alternatively and can preferably be embodied as one single component (for instance an OR-switch, or the multistate switch as disclosed in EP 1 202 427 A1.

[0069] There is a basic device functions means on/off signal 221 for operating switch 206. If the basic device functions means 212 are to be switched off switch 206 is opened. If the basic device functions means are to be switched on switch 206 is closed. Together with the basic device functions 212, the back lighting means are switched. However as explained below in further detail, the adjusting means may be regulated such that the back light current is zero if the basic device functions means have been off and are to be switched on.

[0070] There is an increase or decrease back light current signal 222 for operating the adjusting means 207 which will increase or decrease the back light current. The increase or decrease back light current signal 222 can be an analog signal having a value according to which the adjusting means 202 is to be set. The increase or decrease back light current signal 222 can also be digital, i.e. it can be digital "1" for increasing to back light current and "logical" "0" not decreasing to back light current. In that case the adjusting means 202 will be operated to increase or to decrease the back light current by one step per circle.

[0071] There is an increase or decrease test load current signal 223 for operating the adjusting means 202 which will increase or decrease the test load current. The increase or decrease test load current signal 223 can be realized for instance with one of the options as mentioned in the description of the increase or decrease back light current signal 222.

[0072] Fig. 11 is a flow chart of a preferred embodiment of the method according to the invention.

[0073] First the operation will be described if the loop power is switched on the first time and/or the device is installed for the first time and/or after maintenance thereof.

[0074] If the loop power is switched on, the circuit starts at node 120. At block 101 the charge level of the buffer is checked. If the charge level of the buffer is beneath a low limit of charge a signal will be provided, for instance by the power management controller 211 of Fig. 10, according to which the basic device functions are to be switched off. At the very beginning or after a failure the basic device functions will be already off. In that case the basic device functions will not be switched off but kept off. Thereafter the flow chart will jump to node 121. If in block 101 the buffer charge level is not beneath the low limit of charge, the operation will directly jump to node 121.

[0075] Next the operation continues with block 103 where the output voltage of the power supply is checked. If the output voltage exceeds its set point value, the buffer will be charged for a specific time in block 104. If the output voltage does not exceed the set point value the buffer will be discharged in block 105 for a specific time, but only if the charge level of the buffer is above the low limit.

[0076] From block 105 the operation will jump to node 122. From block 104 where the buffer is charged, the operation goes to block 106 where the voltage of the buffer will be checked. If the buffer voltage does not exceed a high limit, the operation jumps to node 122. Otherwise the operation continues with block 107 where a signal will be provided in order to increase the test load current. Otherwise following node 122 the operation continues with block 108 where a signal is provided to decrease the test load current. It is clear that in blocks 107, 108 the test load current will be increased or decreased, respectively stepwise, i.e. in each cycle of the flow chart one step.

[0077] The height of the step can be predetermined by a fixed parameter. Alternatively the height of the step can be variable in accordance with the current needs such that the test load current is controlled quicker. It will also be possible to switch the test load current completely on or off in each cycle. Furthermore it is clear that the test load current cannot be decreased below zero or increased above a maximum test load current due to the available energy.

[0078] After block 108 the operation jumps to node 123 and further to node 123A. Following block 107 the operation goes to block 109 where the test load voltage will be checked. If the test load voltage does not exceed the operation start limit, the operation jumps to node 123 and further to node 123A. If the test load voltage exceeds the operation start limit the operation goes to block 110 where a signal will be provided to switch the basic device functions on. If the basic device functions are off, the basic device functions will be switched on for the first time. Otherwise they will stay on. Thereafter the operation goes to node 123A. From node 123A the operation goes to block 111 where a test will be made whether the basic device functions are switched on. If the basic device functions are not switched on, the operation goes back to node 120. This cycle will be made as long as the test load voltage does not exceed the operation start limit.

[0079] From the flow chart of Fig. 11 it is clear that the buffer will be charged at the very beginning after the output voltage exceeds the set point value (see block 103). Thereafter the test load current will be increased until the test load current exceeds an operation start limit (see block 109). During increasing the test load current it will be possible that a buffer voltage falls below the high limit and then the buffer will be recharged sometimes.

[0080] In the following the normal operation will be described, i.e. after the basic device functions have been switched on.

[0081] The operation continues with block 112 where the buffer voltage will be checked. If the buffer voltage does not exceed the high limit the operation goes to block 114 where the back light current will be decreased. Thereafter the operation goes to node 124. If in block 112 the buffer voltage does exceed the high limit, the operation continues with block 113 where the back light current will increased.

[0082] Thereafter the operation continues with block 115 where it is checked whether the back light current is at its maximum value. If the back light current is not at its maximum value the operation continues with node 124. Otherwise, i.e. if the back light current is at maximum, the operation continues with block 116 where the test load current will be increased. Thereafter the operation goes to node 125 and jumps back to the beginning on node 120.

[0083] According to the flow chart of Fig. 11 the back light current will be regulated each time the operation runs one cycle (in normal operation). The frequency of one cycle is very fast such the operator will not notice the alteration of the back light current. If the power management controller 211 is embodied with operational amplifiers, the control frequency is about 50 kHz, e.g. 10 - 100 kHz. Normally, it will be sufficient that the alternation frequency of the back light current is higher than 50 Hz. In principle the back light current will be kept at maximum as long as a buffer voltage exceeds the high limit. If the buffer voltage does not exceed the high limit the back light current will be decreased unless the buffer voltage exceeds the high limit again. Therefore the back light current will be high at times the buffer voltage exceeds the high limit, i.e. at times where the basic device functions do not need much energy to be operated.

[0084] As stated above with regard to the test load current, it also will be possible to switch the back light current on and off, in order to simplify the embodiment and/or to increase the frequency of the back light current changes. Instead of increasing the frequency, it will also be possible to increase the step heights.

[0085] A higher speed of the power management controller 211 will improve the stability of the operation voltage 218 as long as the phase shifts are small enough.

[0086] Furthermore, at these times the buffer will be charged up to its maximum. If the buffer is fully charged, the test load current will be increased to sink the energy not needed as long as the back light current is at its maximum. On the other hand, if the basic device functions need more energy, the back light current will be decreased after the buffer voltage drops below a high limit. Normally, the buffer charge will not fall below a low limit such that the basic device functions will be switched off. The basic device functions, i.e. sensors and/or actuators (they normally do not need so much energy) must be designed such that they do not sink more average in the average than the loop power can provide in order to avoid that the buffer will be emptied beneath a low limit of charge.

[0087] For embodiments where the actuator needs much energy for a long time it is recommended to increase the buffer size accordingly.

Claims

1. Operation voltage controller for a signal powered field device having a display, comprising

a power supply for transforming the signal into a high voltage output and a low voltage output, and
a basic device functions means being supplied by the low voltage output such that an operation voltage is applied at the basic device functions means,

characterised by a back lighting means for back lighting a display of the signal powered field device.

2. Operation voltage controller of claim 1, wherein the back lighting means comprises at least one light emitting diode, preferably a plurality of light emitting diodes and more preferred three light emitting diodes.

3. Operation voltage controller of any of the preceding claims, wherein the back lighting means comprises a back light current adjusting means for adjusting the back light current depending on the operation voltage applied at the basic device functions means.

4. Operation voltage controller of the preceding claim, wherein the back light current is decreased if the operation voltage is below a preset level and increased if the operation voltage exceeds the preset level.

5. Operation voltage controller of any of the preceding claims, further comprising a buffer designed and adapted to be charged by connecting the buffer to the high voltage output and designed and adapted to be discharged by connecting the buffer to the low voltage output, wherein the back lighting means comprises a back light current adjusting means for adjusting the back light current depending on the charge level of the buffer.

6. Operation voltage controller of the preceding claim, wherein the back light current is decreased, if the charge level of the buffer is below a preset level, preferably a high limit of charge, and increased, if the charge level of the buffer exceeds the preset level.

7. Operation voltage controller of any of the two preceding claims, wherein the buffer will be charged, if the output voltage exceeds a set point value, and the buffer will be discharged, if the output voltage does not exceed a set point value.

8. Operation voltage controller of any of the three preceding claims, wherein the buffer comprises a capacitor, an accumulator and/or a battery.

9. Operation voltage controller of any of the preceding claims, further comprising a test load for sinking excess energy by applying a test load voltage to the test load such that a test load current is flowing through the test load.

10. Operation voltage controller of the preceding claim, wherein the test load current is increased, if the back light current is at its maximum, and the test load current is decreased, if the back light current is below its maximum.

11. Operation voltage controller of any of the two preceding claims, wherein the test load current is increased, if the buffer voltage exceeds a high limit, and the test load current is decreased, if buffer voltage does not exceed the high limit.

12. Operation voltage controller of any of the preceding claims, further comprising a power management controller for controlling the charge level of the buffer, the back light current and/or the test load current.

13. Operation voltage controller of the preceding claim, wherein the power management controller is supplied with energy by the high voltage output and/or the low voltage output.

14. Operation voltage controller of any of the preceding claims, wherein the back lighting means comprises a reflector.

15. Operation voltage controller of the preceding claim, wherein the reflector is designed and adapted for reflecting light emitted from a light source to the display of the signal powered field device and for providing a support for the display such that the display is located in a specific distance above a printed circuit board onto which the light source is mounted.

16. Signal powered field device comprising an operation voltage controller of any of the preceding claims.

17. Signal powered field device of the preceding claim, further comprising an explosion proof and/or flame proof and/or pressure tight housing, preferably comprising a window for the display.

18. Signal powered field device of any of the preceding claims, wherein the operation voltage controller comprises at least one switch mounted on a printed circuit board and the housing comprises a corresponding number of actuating means for actuating the switch or switches through the wall of the housing.

19. Method for controlling an operation voltage controller of a signal powered field device having a display, wherein the operation voltage controller comprises at least a basic device functions means, the method comprising the following steps:

transforming the signal into a high voltage output and a low voltage output, and
supplying the basic device functions means with the low voltage output such that an operation voltage is applied at the basic device functions means,

characterised by back lighting a display of the signal powered field device.

20. Method of the preceding claim, wherein the back lighting is made by means of at least one light emitting diode, preferably by means of a plurality of light emitting diodes and more preferred by means of three light emitting diodes.

21. Method of any of the two preceding claims, wherein a back light current is adjusted depending on the operation voltage applied at the basic device functions means.

22. Method of the preceding claim, wherein the back light current is decreased, if the operation voltage is below a preset level, and increased, if the operation voltage exceeds the preset level.

23. Method of any of the four preceding claims, wherein the operation voltage controller further comprises a buffer, wherein the buffer is charged by connecting the buffer to the high voltage output and discharged by connecting the buffer to the low voltage output, wherein the back lighting means comprises a back light current adjusting means for adjusting the back light current depending on the charge level of the buffer.

24. Method of the preceding claim, wherein the back light current is decreased, if the charge level of the buffer is below a preset level, preferably a high limit of charge, and increased, if the charge level of the buffer exceeds the preset level.

25. Method of any of the two preceding claims, wherein the buffer is charged, if the output voltage exceeds a set point value, and the buffer is discharged, if the output voltage does not exceed a set point value.

26. Method of any of the seven preceding claims, further comprising the step of sinking excess energy by applying a test load voltage to a test load of the operation voltage controller such that a test load current is flowing through the test load.

27. Method of the preceding claim, wherein the test load current is increased, if the back light current is at its maximum, and the test load current is decreased, if the back light current is below its maximum.

28. Method of any of the two preceding claims, wherein the test load current is increased, if the buffer voltage exceeds a high limit, and the test load current is decreased, if the buffer voltage does not exceed the high limit.

29. Method of any of the ten preceding claims, further comprising the step of switching the basic device functions on, if the test load voltage exceeds an operation start limit.

30. Method of any of the eleven preceding claims using an operation voltage controller in accordance with any of the claims 1 to 15 and/or a signal powered field device in accordance with any of the claims 16 to 18.

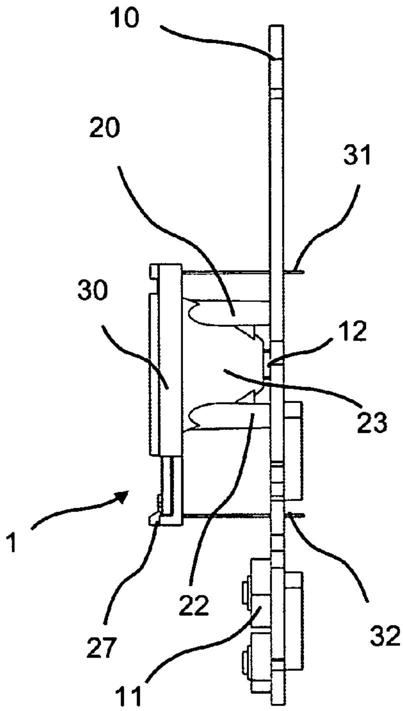

Fig. 1

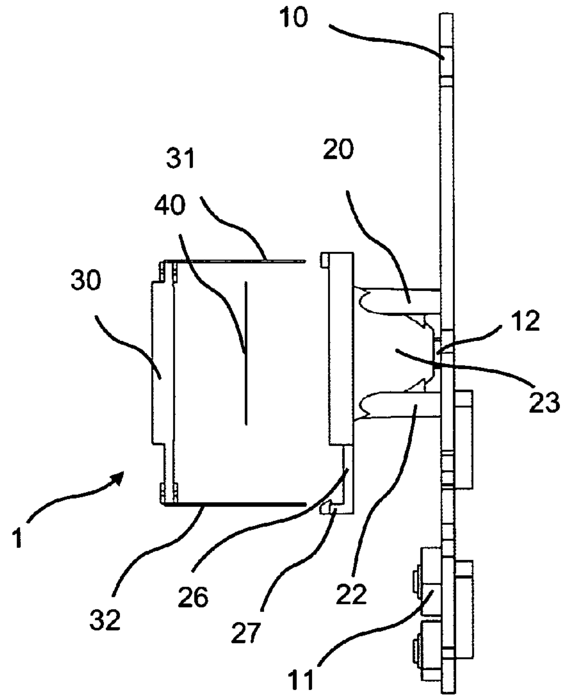

Fig. 2

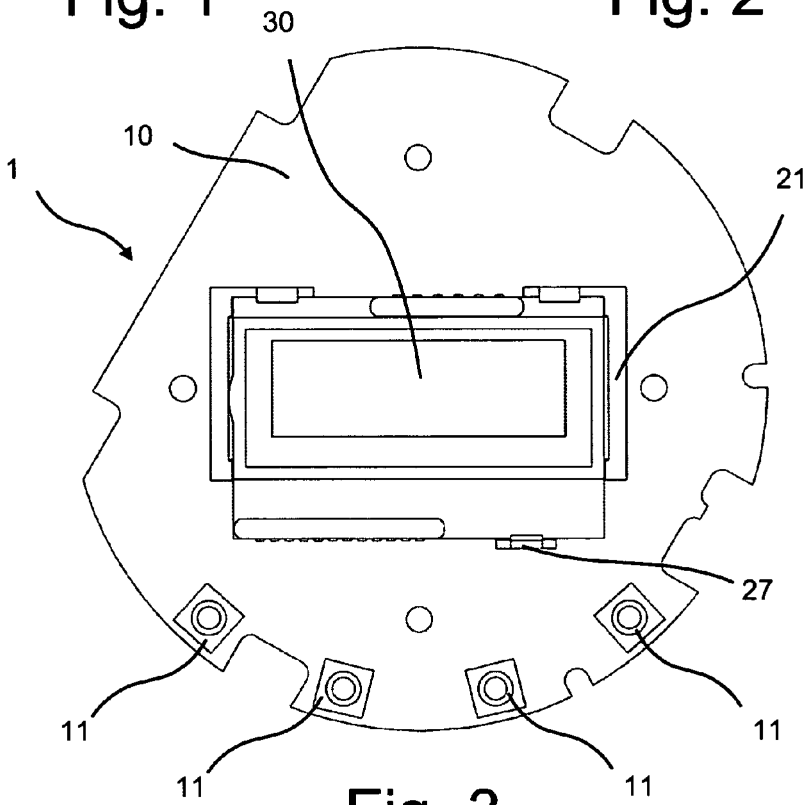

Fig. 3

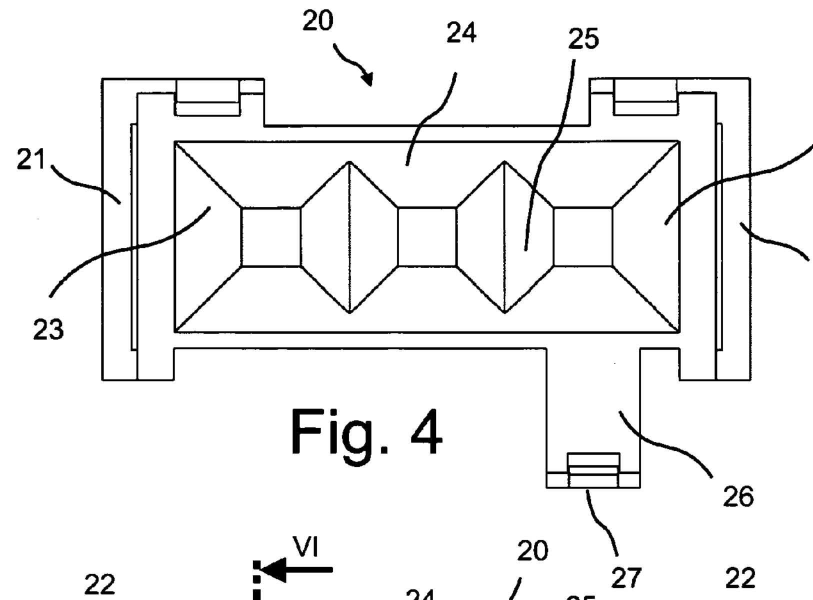

Fig. 4

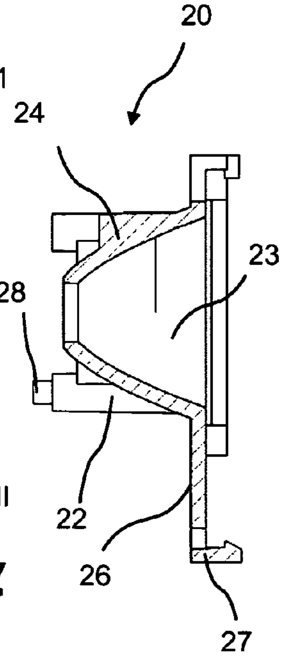

Fig. 6

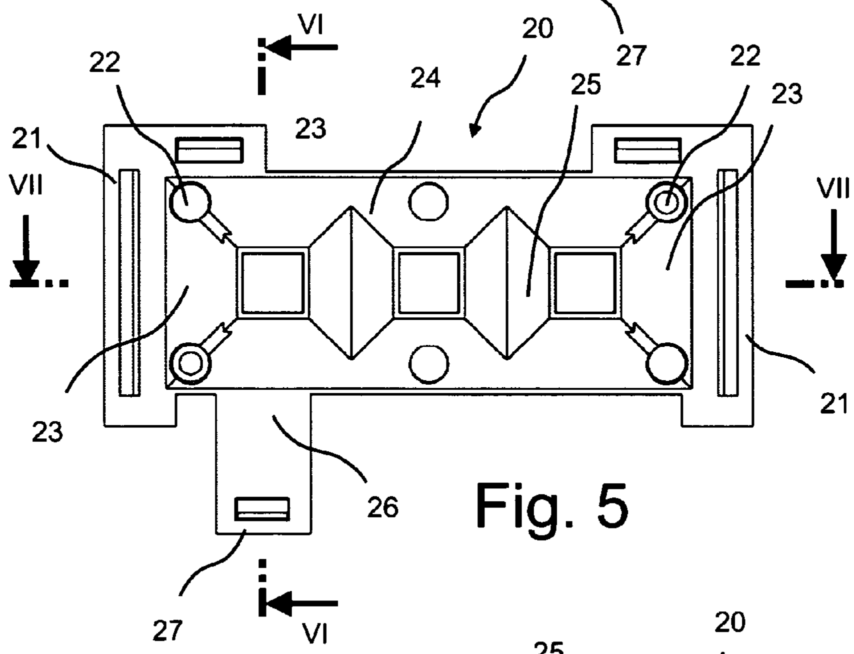

Fig. 5

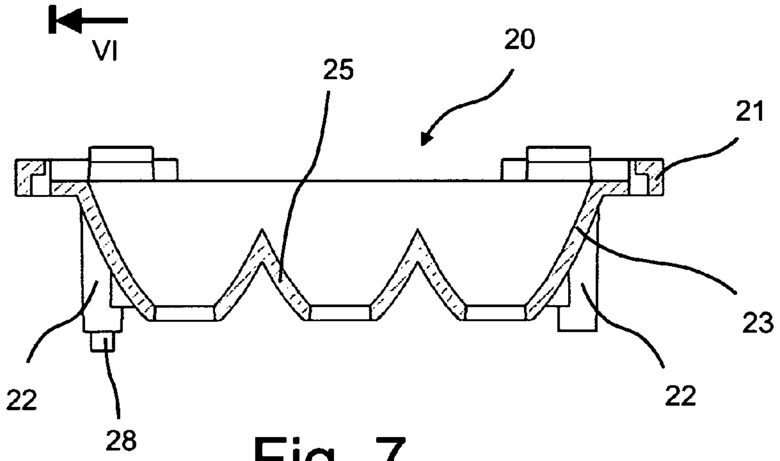

Fig. 7

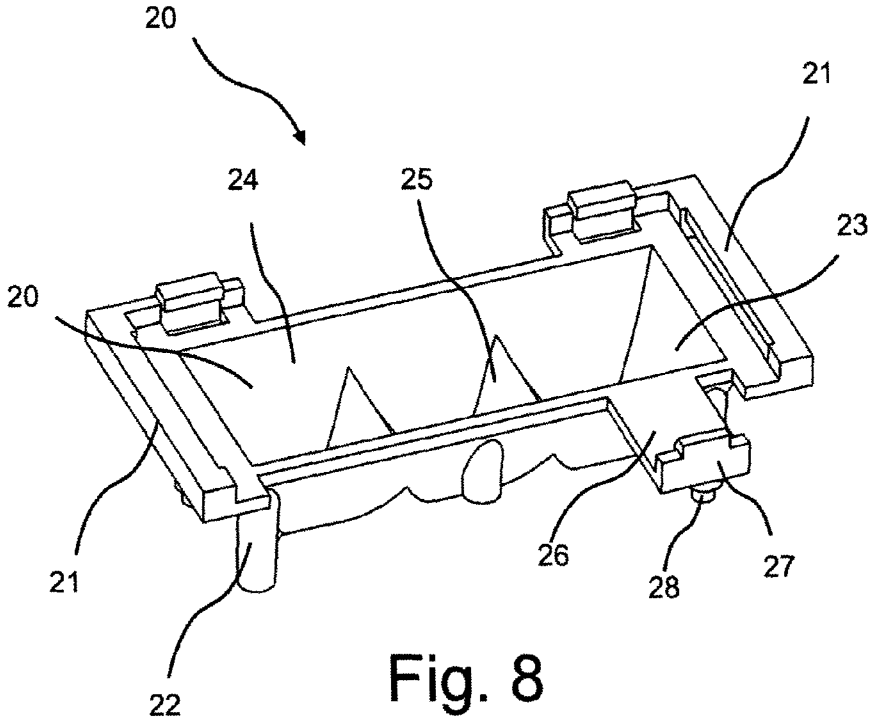
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Fig. 8

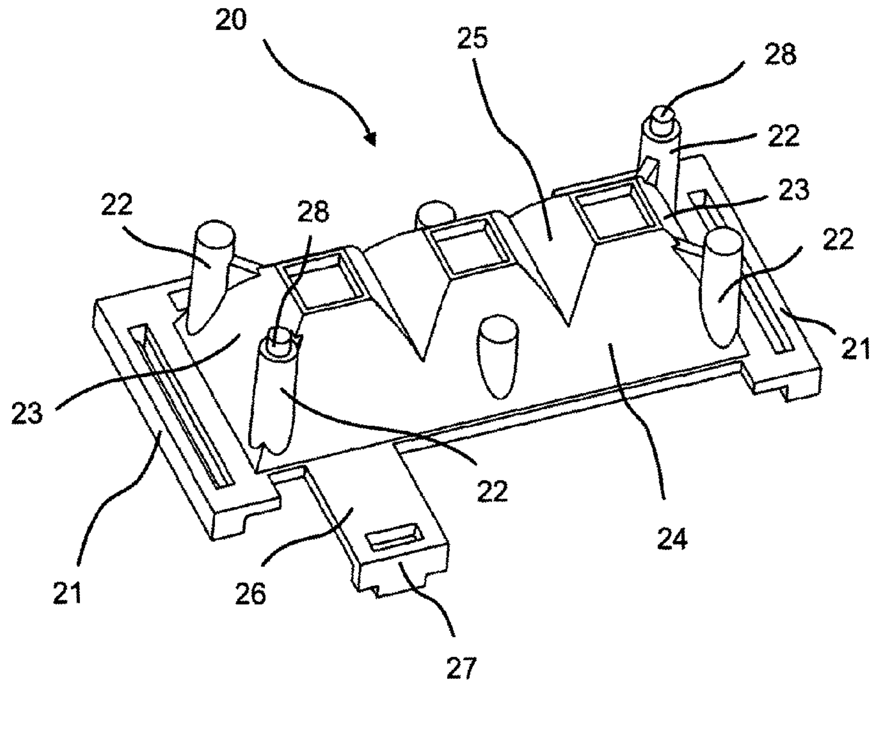
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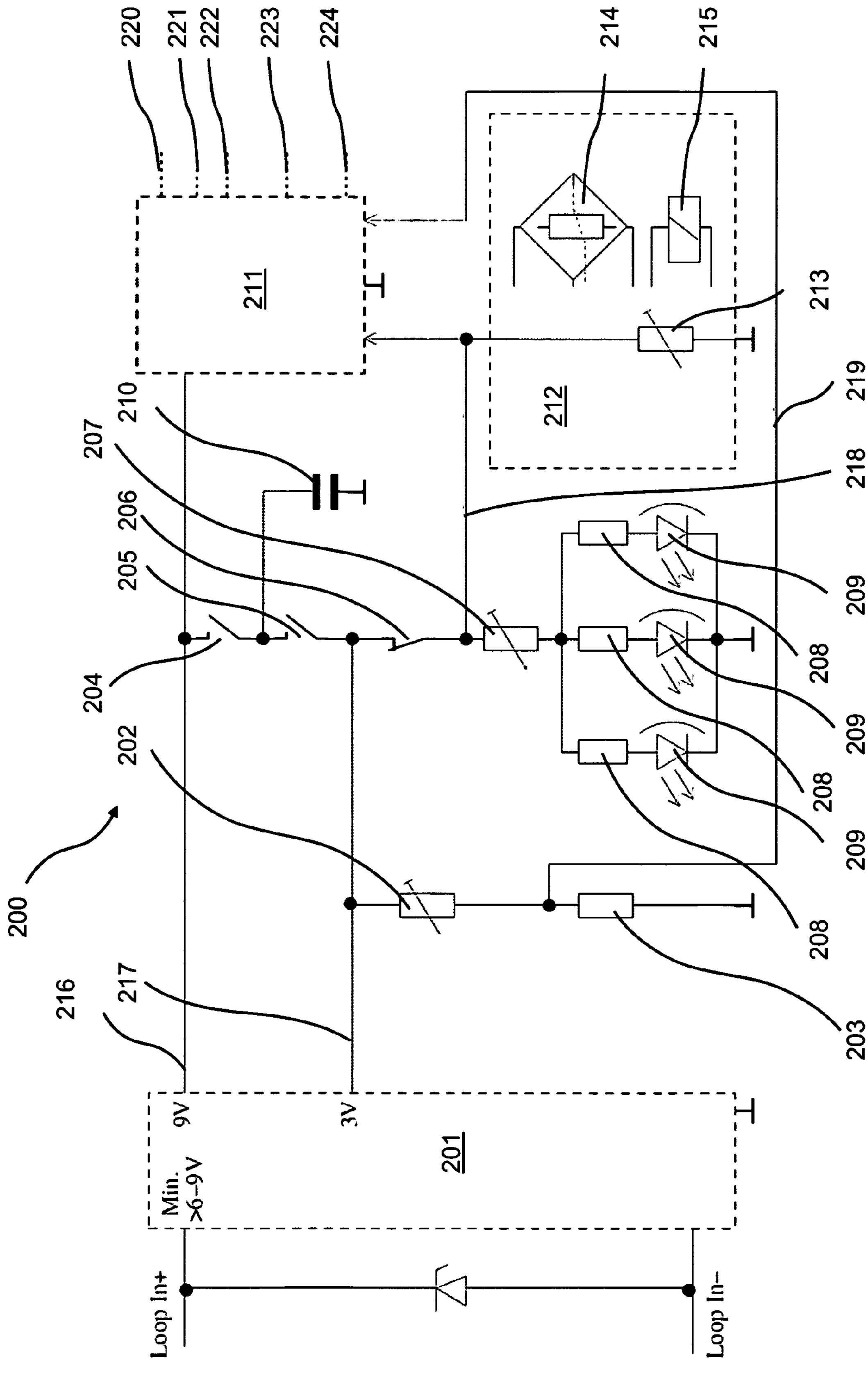
Fig. 9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206
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210
211
212
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214
215
216
217
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219
220
221
222
223
224
Loop In+
Loop In-
Min.
>6–9V
9V
3V

Fig. 10

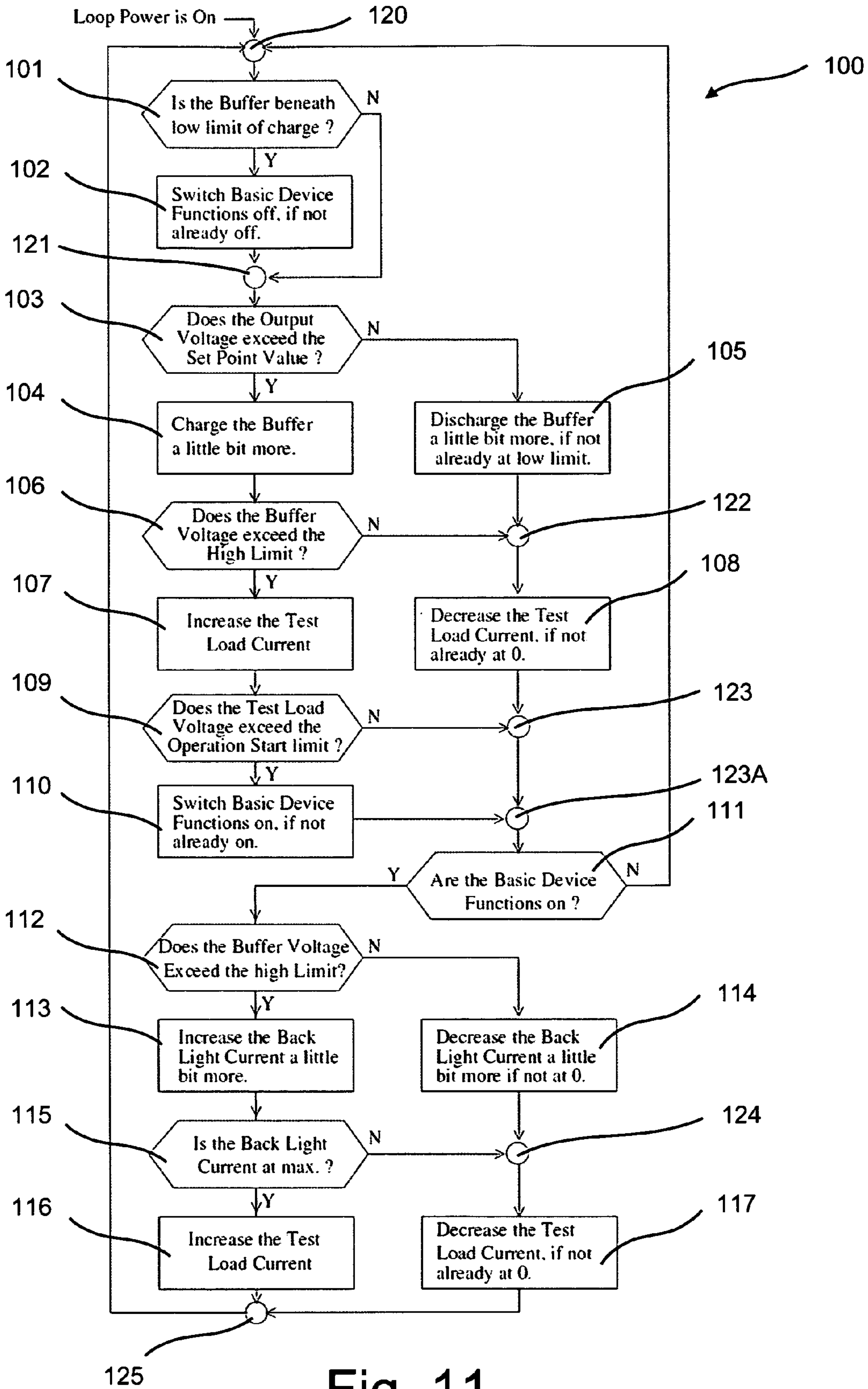
Loop Power is On
120
100
101
Is the Buffer beneath low limit of charge ?
N
Y
102
Switch Basic Device Functions off, if not already off.
121
103
Does the Output Voltage exceed the Set Point Value ?
N
Y
105
104
Charge the Buffer a little bit more.
Discharge the Buffer a little bit more, if not already at low limit.
106
Does the Buffer Voltage exceed the High Limit ?
N
122
Y
108
107
Increase the Test Load Current
Decrease the Test Load Current, if not already at 0.
109
Does the Test Load Voltage exceed the Operation Start limit ?
N
123
Y
123A
110
Switch Basic Device Functions on, if not already on.
111
Y
Are the Basic Device Functions on ?
N
112
Does the Buffer Voltage Exceed the high Limit?
N
Y
113
Increase the Back Light Current a little bit more.
114
Decrease the Back Light Current a little bit more if not at 0.
115
Is the Back Light Current at max. ?
N
124
Y
116
Increase the Test Load Current
117
Decrease the Test Load Current, if not already at 0.
125

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 07 01 4826

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2007/161273 A1 (STAIGER HOLGER [DE]) 12 July 2007 (2007-07-12) * abstract * * paragraph [0002] * * paragraphs [0025], [0032], [0034] * * paragraphs [0048], [0050]; figure 7 * * paragraphs [0097] - [0103]; figure 9 * -----	1,2,5,8, 16-20, 23,30	INV. G09G3/34
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			G09G H05B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	2 January 2008	Adarska, Veneta

CATEGORY OF CITED DOCUMENTS

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02-01-2008

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