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(54) Title: SAR LIMIT COMPLIANT CONSUMER DEVICE

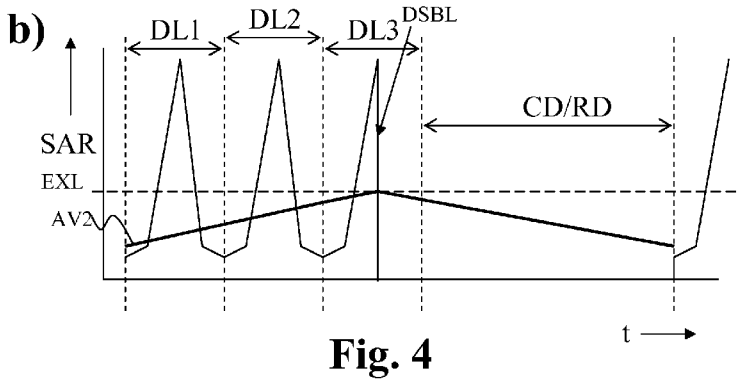

Fig. 4

(57) Abstract: The invention relates to a method of operating a consumer device (100) having a wireless transmitter (90) for communicating with an external device through an antenna (95), the consumer device (100) being operated by a user, the method comprising: i) communicating with the external device through the antenna (95), ii) determining an indicator that is indicative for a specific absorption rate (SAR) of the user during operational use of the consumer device (100) to obtain a determined indicator (AVI, AV2, AV3, AV4), wherein the specific absorption rate (SAR) is a measure of a rate at which energy is absorbed by a body of the user, and iii) controlling the communicating according to the determined indicator (AVI, AV2, AV3, AV4) to prevent the indicator to exceed a predefined exposure limit (EXL). The invention also relates to a computer program product comprising instructions for causing a processor to perform such method. The invention further relates to a consumer device configured for carrying out such method. The method and the consumer device in accordance with the invention provide for a reduced SAR of the user of the consumer device.

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SAR limit compliant consumer device

FIELD OF THE INVENTION

The invention relates to a method of operating a consumer device having a wireless transmitter for communicating with an external device through an antenna, the consumer device being operated by a user. Such method comprises: communicating with the external device through the antenna. The invention further relates to a computer program product comprising instructions for causing a processor to carry out such method. The invention also relates to a consumer device configured for carrying out such method. The invention is particularly interesting in the field of portable devices which are held close to a body part, such as on the lap, in operational use. Examples of such portable devices are game consoles, laptops, PDA's, digital photo frames, and display devices, such as E-readers and mobile phones.

BACKGROUND OF THE INVENTION

A consumer device of the type mentioned in the opening paragraph is known from the international patent application US2006/0227196. This patent application discloses an electronic ink display which comprises two substrates. One of the substrates is transparent and is provided with a single electrode which is referred to as the counter electrode. This counter electrode is in other literature also referred to as common electrode or backplane electrode. The other substrate is provided with picture electrodes which comprise row and column electrodes. A display element or pixel is associated with an intersection of a row electrode and a column electrode. A pixel electrode of the display element is coupled to the column electrode via a thin film transistor (further referred to as TFT), the gate of which is coupled to the row electrode. This arrangement of display elements, TFT transistors and row and column electrodes together forms an active matrix. A row driver sequentially selects rows of display elements and the column driver supplies data signals to the selected row of display elements via the column electrodes and the TFT transistors. The data signals correspond to graphic data to be displayed.

An electronic ink is provided between the pixel electrode and the common electrode. The electronic ink comprises multiple microcapsules of about 10 to 50 microns. Each microcapsule comprises positively charged white particles and negative charge black particles suspended in a fluid. When a positive voltage is applied to the pixel electrode with respect to the common electrode, the positively charged white particles move to the side of the micro capsule directed to the transparent substrate on which the

common electrode is present and a viewer will see a white display element. Simultaneously, the black particles move to the pixel electrode at the opposite side of the microcapsule where they are hidden to the viewer. By applying a negative voltage to the pixel electrode with respect to the common electrode, the black particles move to the common electrode at the side of the micro capsule directed to the transparent substrate and the display element appears dark to a viewer. When the voltage is removed, the display device remains in the acquired state and thus exhibits a bi-stable character. The electronic ink display with its black and white particles is particularly useful as an electronic book.

Grey scales are created in the display device by controlling the amount of particles that move to the common electrode at the top of the microcapsules. For example, the energy of the positive or negative electric field in the pixel caused by the voltage difference between the pixel and common electrodes, defined as the product of field strength and time of application, controls the amount of particles moving to the top of the microcapsules.

A multi-level drive of the pixel electrodes enables to more closely reach a desired light output of a pixel because it is possible to more accurately control the movement of the particles at a lower value of the drive voltage. However, such a multi-level drive of the pixel electrodes requires complex display drivers.

GB2454030A discloses an electronic document reading device that is a device such as an electronic book which presents a document to a user on a display to enable the user to read the document. In particular, a display device is disclosed for displaying an electronic document page comprising a central rewritable portion, a non-rewritable border with external lateral physical dimensions defined by the display edges, wherein said border is colored to substantially match a background color of said central rewritable portion such that when a foreground part of said document page is displayed on said central rewritable portion the appearance of margins of said document page is provided by said background colored border. As a consequence, in use, said displayed electronic document page appears to extend up to said display edges, and wherein the surface of the display is substantially flat over the lateral physical dimensions from the central rewritable portion across the border to the display edges. The device may be controlled via a touch sensitive interface.

A problem of the known electronic document reading device is that their wireless interfaces result in expose of the user to RF energy. Particularly, in case of prolonged and intense usage, the amount of RF energy to which the user is exposed, i.e. the Specific Absorption Rate (SAR), may reach levels which are inconvenient (heat sensation) or even dangerous for the user.

SUMMARY OF THE INVENTION

It is a first object of the invention to provide a method of operating a consumer device in which the SAR is reduced. It is a second objection of the invention to provide a display device comprising a display panel which is configured for carrying out such method.

The invention is defined by the independent claims. The dependent claims define advantageous embodiments.

In a first aspect, in accordance with the first object, the invention relates to a method as claimed in claim 1.

The effect of the features of the invention is as follows. The Specific Absorption Rate (SAR) is generally used as a measure of safe exposure to radiofrequency (RF) energy for mobile devices, i.e. the amount of radio frequency energy absorbed by a user's body while operating a mobile device (over a period of time). Various governments have defined safety limits for exposure to radiofrequency energy produced by the wireless mobile device. For example, for mobile devices that mainly exposes the head or a limb for RF energy, in the USA, the FCC requires that phones sold have a SAR level at or below 1.6 watts per kilogram (W/kg) taken over a volume of 1 gram of tissue and in European Union, CENELEC specify SAR limits within the EU, following IEC standards. For mobile phones and other hand-held devices, the SAR limit is 2 W/kg average over 10 gram of tissue (IEC 62209-1). Device manufacturers are requested to ensure their products comply with these objective limits for safe exposure. In the example of US market, the FCC limit for public exposure from a mobile device is a SAR of 1.6 W/kg, measured at a certain distance from the device at a certain usage situation. For example, on a cell-phone this is with the device against the user's ear. During operational use the consumer device communicates, upon a command of the user such as a download or browsing command, with an external device (such as a server on internet) through the antenna. During this communication the user is exposed to RF energy emitted by the antenna, i.e. with the Specific Absorption Rate (SAR). With the method of the invention the SAR is kept low by determining an indicator that is indicative for the SAR of the user during operation use. When the indicator is getting too large, the communication with the external device is controlled such that it is prevented that the predefined exposure limit is exceeded. By doing so the SAR is kept within predefined limits. Different embodiments for reducing the indicator (and thereby the average SAR) exist and will be discussed hereinafter.

The effect of the invention becomes even more pronounced in cases where the consumer device is relatively thin, because in such devices the antenna is located

closer to the human body and thus the human body is exposed to more RF energy when the antenna is active.

In an embodiment of the method in accordance with the invention the communicating with external device through an antenna is activated by the user.

In an embodiment of the method in accordance with the invention the controlling of the communicating according to the determined indicator comprises disabling the communicating once the indicator has exceeded a predefined exposure limit. This is a very simple and effective method of preventing the predefined exposure limit to be exceeded.

In an embodiment of the method in accordance with the invention the controlling of the communicating according to the determined indicator comprises reducing communicating power of the antenna once the indicator is within a predefined distance from the predefined exposure limit. The advantage of this embodiment is that potential frustration of the user is prevented as the following situation is avoided in a display device for example: when the user is halfway of downloading a book while the SAR is close to the limit, the display device forces breaking the connection and the downloading is stopped, which renders the complete downloading action useless.

In an embodiment of the method in accordance with the invention the communication power is reduced by reducing communication bandwidth or by reducing an antenna signal. These are two very effective methods of reducing the communication power of the antenna.

In an embodiment of the method in accordance with the invention the controlling of the communicating according to the determined indicator comprises estimating remaining communication time and determining if the predefined exposure limit is to be exceeded within this remaining communication time, the controlling further comprises taking an appropriate measure to prevent the predefined exposure limit to be exceeded. This estimation may be done before or during the communicating. It may be done once or continuously during the communicating. In a first variant of this embodiment download time is estimated from a file size, which file is to be downloaded, and a download rate. In a second variant the remaining communication time is estimated by maintaining and using a download history in which download figures are stored, such as average download time per download.

In an embodiment of the method in accordance with the invention the appropriate measure comprises postponing further communication with a predefined delay time such that the predefined exposure limit is no longer expected to be exceeded within the remaining communication time. Postponing further communication will be less

frustrating for the user than interruption of the communication which may renders an action (such as a download action) useless. In an alternative embodiment appropriate action comprises reducing the communication power in accordance with an earlier mentioned-embodiment.

In an embodiment of the method in accordance with the invention the disabling comprises disabling the wireless transmitter. The disabling of the wireless transmitter is a convenient way of disabling the communication. Such event may be triggered by a simple instruction from the processor in the consumer device. Obviously, other ways of disabling exist as well, such as switching off parts of the consumer device, termination of the execution of the (embedded) software, etc.

In an embodiment of the method in accordance with the invention the determining of the indicator comprises taking a time-average of a specific absorption rate during operational use of the consumer device. The advantage of this embodiment is that it enables the consumer device to operate above the predefined exposure limit temporarily, as long as the time-average SAR does not increase above said predefined exposure limit. This embodiment of the invention is particularly interesting in consumer devices where the activity of the antenna is bursty, i.e. short time periods with high activity between relatively long periods of inactivity or very low activity.

In an embodiment of the method in accordance with the invention the taking of the time-average comprises averaging the specific absorption rate over a time-window with a predefined length. Setting the length of the time-window over which the SAR is averaged, determines how long the consumer device will remember activity of the antenna. The longer the time-window, the longer it will remember the activity, but this is at the cost of more storage required for remembering said activity. Also, the tolerance for RF energy peaks becomes higher if the time-window is longer. The shorter the time-window is set the smaller the storage space required for storing said activity. Also, the tolerance for RF energy peaks becomes less.

In an embodiment of the method in accordance with the invention the predefined length of time-window is specified by the user. The user may desire to deviate from the standards set by the respective authorities, for example the time-window may be set shorter. This embodiment provides a convenient solution for this.

In an embodiment of the method in accordance with the invention the determining of the indicator comprises: i) measuring RF power received by a sensor placed on or near a body part of the user to obtain a measured RF power, and ii) determining the indicator from the measured RF power. This embodiment constitutes a first variant of determining the indicator. The advantage is that a more accurate estimation of the SAR by the body of the user is obtained.

In an embodiment of the method in accordance with the invention the determining of the indicator comprises: i) monitoring RF power emitted by the antenna to obtain an emitted RF power, and ii) determining the indicator from the emitted RF power. This embodiment constitutes a second variant of determining the indicator. The advantage is that no sensor is required.

In an embodiment of the method in accordance with the invention the determining of the indicator comprises: i) obtaining an estimate of the specific absorption rate from a user-absorption model stored in the consumer device, wherein the human-absorption model comprises information about the relation between RF power emitted by the antenna and the specific absorption rate given a specific use of the consumer device. The human-absorption model may be obtained from measurements carried out in a laboratory in which a magnetic sensor is placed on a body part of the user. The user holds and operates the consumer device and the sensor measures the RF power received by the sensor. This RF power is then indicative for the power emitted by the antenna. The human-absorption model may be stored in a look-up-table (LUT) in the consumer device.

An embodiment of the method in accordance with the invention further comprises: re-enabling the communicating once a cool-down period has lapsed starting from the disabling of the wireless transmitter. In order to safe-guard that the SAR limit is not immediately violated again upon activation this embodiment of the method provides for a cool-down period such that the (average) SAR is reduced to levels well below the predefined exposure limit.

In an embodiment of the method in accordance with the invention the re-enabling comprises re-enabling the wireless transmitter. Such event may be triggered by a simple instruction from the processor in the consumer device. Obviously, other ways of re-enabling exist as well, such as switching on parts of the consumer device, restarting of the execution of the (embedded) software, etc.

In an embodiment of the method in accordance with the invention the length of the cool-down period is determined by the predefined exposure limit. In a further variant the cool-down period is made dependent from the predefined exposure limit such that a higher value of the predefined exposure limit results in a longer cool-down period.

In an embodiment of the method in accordance with the invention the predefined exposure limit is specified by the user. The user may desire to deviate from the standards set by the respective authorities, for example the predefined exposure limit may be set lower. This embodiment provides a convenient solution for this.

In an embodiment of the method in accordance with the invention the predefined exposure limit is chosen to comply with safety standards. This embodiment

may be combined with the previous embodiment in that the user specified value may be checked upon violation of the safety standards.

In a second aspect, the invention relates to a computer program product comprising instructions for causing a processor to perform the method in accordance with the invention.

In a third aspect, in accordance with the second object, the invention relates to a consumer device as claimed in claim 21. The consumer device is configured for carrying out the method of the invention and has therefore corresponding embodiments having similar advantages as the method. In the description of the figures an example of a display device is further discussed. It will be apparent for the person skilled in the art that in particular for the display device many variations are possible. Different functions may be shifted amongst different blocks, or intentionally merged into one block. Furthermore, the functions may be implemented in software, in hardware, or mixtures of both.

An embodiment of the consumer device comprises a display device for displaying an electronic document.

In an embodiment of the consumer device in accordance with the invention comprises, the display device comprises the wireless transmitter and a microprocessor, wherein the microprocessor is configured for carrying out the method in accordance with the invention.

In an embodiment of the consumer device in accordance with the invention, the display device comprises a display panel selected from a group comprising: an LCD display panel, a bi-stable LCD display panel, an electrowetting display panel, a bi-stable electrowetting display panel, and an electrophoretic display panel.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 shows a display device in accordance with an embodiment of the invention;

Fig. 2 shows a block diagram of the display device of Fig. 1;

Fig. 3 shows a formula for calculating the SAR;

Figs. 4a to 4d illustrate different embodiments of the method and consumer device in accordance with the invention;

Fig. 5 illustrates implementation aspects of an embodiment of the method in accordance with the invention;

Fig. 6 shows diagrammatically a cross-section of a portion of an electrophoretic display device, and

Fig. 7 shows diagrammatically an equivalent circuit diagram of a portion of the electrophoretic display device.

List of reference numerals:

1	electrophoretic matrix display panel
2	base substrate
3	transparent substrate
4	transparent substrate
5, 5'	transparent picture electrodes
6	common electrode
7	micro capsule
8	white particles
9	black particles
10	row driver
11	column or data electrodes
12	drive lines
13	(incoming) display data
15	processor
16	column driver
17	row or select electrodes
18	display element
19	active switching elements
20	gate electrodes
21	source electrodes
22	pixel electrodes
23	capacitor
24	storage capacitor lines
25	backplane driver
26	control signals
29	polymeric binder
VD	data signal
VG	gate electrode voltage
VP	voltage from backplane driver

50	display panel
60	microprocessor
70	non-volatile document storage medium (memory card)
80	main memory (SDRAM)
90	RF modem
95	RF antenna
99	device control buttons of display device
100	display device
5 1	step of reading an electronic document
S2	step of rendering a page to be displayed
S2'	step of fetching a page to be displayed
5 3	step of transfer the rendered page from memory to the display panel
5 4	step of displaying the rendered page on the display panel
5 5	step of downloading an electronic document from the internet into the main memory
5 6	step of writing the electronic document onto the non-volatile memory
SAR	Specific Absorption Rate
t	time
σ	sample electrical conductivity
p	sample density
E	RMS electric field
DL1	first download time period
RD1	first read time period
DL2	second download time period
RD2	second read time period
DL3	third download time period
CD/RD	cool-down time (read-time)
DT	delay time
EXL	predefined exposure limit
AV1	SAR moving average of first scenario
AV2	SAR moving average of second scenario
AV3	SAR moving average of third scenario
AV4	SAR moving average of fourth scenario
DSBL	moment at which the communication is disabled
CTRL	moment at which the communication is controlled
USRS	user software
CM	connection manager

PPPN	PPP network (point-to-point protocol)
SSW	SAR monitoring software

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In order to facilitate the discussion of the detailed embodiments a few expressions are defined hereinafter.

The specific Absorption Rate (SAR) is generally used as a measure of safe exposure to radiofrequency (RF) energy for mobile devices, i.e. the amount of radio frequency energy absorbed by a user's body while operating a mobile device (over a period of time). Various governments have defined safety limits for exposure to radiofrequency energy produced by the wireless mobile device. For example, for mobile devices that mainly exposes the head or a limb for RF energy, in the USA, the FCC requires that phones sold have a SAR level at or below 1.6 watts per kilogram (W/kg) taken over a volume of 1 gram of tissue and in European Union, CENELEC specify SAR limits within the EU, following IEC standards. For mobile phones and other hand-held devices, the SAR limit is 2 W/kg average over 10 gram of tissue (IEC 62209-1). Device manufacturers are requested to ensure their products comply with these objective limits for safe exposure. In the example of US market, the FCC limit for public exposure from a mobile device is a SAR of 1.6 W/kg, measured at a certain distance from the device at a certain usage situation. For example, on a cell-phone this is with the device against the user's ear. However, on consumer devices such as an electronic book reader, the expected usage situation is with the device placed on the user's lap. This results in a relatively high SAR, since the user's body is typically less than 1cm away from the radiating antenna. As a result, the SAR in this situation will typically be above the limit of 1.6W/kg, in particular at a constant ON mode.

The invention proposes to monitor the SAR, either directly or indirectly, and control the communication such that the predefined exposure limits is not exceed, at least not when considering a certain time period. Instantaneous SAR levels higher than the predefined exposure limits are allowed, as long as the average SAR is below the prescribed limit. The prescribed limits may be set by the user or may be taken from market standards. The invention is applicable to both scenarios.

The invention may be implemented as a computer program that is pre-installed in the consumer device. It may be stored in an internal memory or external memory and executed on a CPU.

The discussion of the invention which follows hereinafter is based upon a display device having a bi-stable display panel. It must be stressed that this is just an

example of a consumer device in which the invention may be implemented. The invention is not limited to such display devices per se.

Fig. 1 shows a display device in accordance with an embodiment of the invention. The figure is purely schematic in order to explain important aspects of the invention. The display device 100 comprises a bi-stable display panel, such as an electrophoretic display panel (E-ink, E-paper). It must be stressed that the invention is broader applicable than in the field of bi-stable display panel; the invention is applicable in any display device where the processing power is kept low for power consumption reasons, for example in a portable device running on a battery. The display device 100 further comprises device control buttons 99, in this example located at the left side and the bottom side of the device (but this is not essential to the invention). The bi-stable display panel is divided into a display panel 50 located in the middle of the device.

Fig. 2 shows a block diagram of the display device of Fig. 1. The display device 100 comprises the bi-stable display panel 50, a main memory 80 and a microprocessor 60 coupled to the main memory 80 and the display panel 50. The display device 100 further comprises a non-volatile document storage medium 70 (such as a memory card) that is also coupled to the microprocessor 60. The bi-stable display device 100 further comprises a wireless transmitter 90 (such as a wireless modem) that is coupled to an antenna 95. The coupling of the respective blocks in Fig. 2 has been schematically illustrated by bold arrows. The display device 100 operates as follows. The microprocessor 60 plays a central role in the displaying as it performs and triggers many operations.

In a first sub-step S1 an electronic document, such as a PDF-file or an html-file, is read from the non-volatile memory 70 into the main memory 80 (such as a DDR SDRAM). This step typically takes a second up to several seconds, depending on the size of the electronic document. The electronic document comprises a plurality of pages, which document is, as such, not displayable in images (instead it is displayable in some sort of document code, wherein the layout of the pages is not recognizable).

In a second sub-step S2 a first one of the plurality of pages is selected and rendered from the electronic document so that a first rendered page is obtained. The rendering is carried out by the microprocessor and the resulting rendered page is stored in the main memory 80. Such rendering step may typically take 800ms for a text page in an electrophoretic display device. In practical documents, it may take several hundreds of milliseconds up to a few seconds or even more than 10 seconds, depending on the complexity of the data of the page to be displayed.

In a third sub-step S3 the first rendered page is transferred to the display panel 50, which may typically take about 20ms for an electrophoretic display device. In

Fig. 2 this transfer has been illustrated by an arrow through the microprocessor. This is not essential, however, as in some embodiments the main memory 80 may have direct connections with the bi-stable display panel 50, wherein said transfer is triggered by the microprocessor but not through the microprocessor.

In a fourth sub-step S4 the first rendered page is displayed on the bi-stable display panel 50, which may typically take about 800ms for an electrophoretic display panel.

Until this point the described steps merely illustrate a read operation of the user, i.e. the user selects and reads a book on the display device. However, sometimes the user may desire to buy a new book, which can be done by downloading it from the internet. The communication with the internet is taken care of by the wireless transmitter 90 and the antenna 95.

Downloading a book from the internet is illustrated by the fifth sub-step S5. In this operation the microprocessor 60 instructs the wireless transmitter 90 to establish an internet connection and to download the content from a specific location on the internet. During this action data is received by the antenna 95 and transferred by the wireless transmitter 90 to the processor 60 which stores the data in the internal memory 80 for example. It is precisely this kind of actions which exposes the user to a certain amount of radiation (the SAR), namely radiation that is emitted to the antenna 95, but also radiation that is received by the antenna 95 (and emitted by a wireless internet base-station (not shown) located elsewhere). It may be stated that the antenna 95 concentrates the radiation and when the display device is on the user lab for example, the user will experience heat that is caused by the radiation. Safety standards have been set to protect the user for radiation levels which are too high. Products have to comply with these safety standards in order to be allowed on the market. Alternatively, it may be that a specific user desires to set the radiation level even lower than what is prescribed by the safety standards. In both cases the invention provides for a solution.

In a sixth sub-step S6 the downloaded content may be stored on the non-volatile document storage medium 70 so that the user is able to read the content at a later time.

Fig. 3 shows a formula for calculating the SAR. The Specific absorption rate (SAR) is a measure of the rate at which energy is absorbed by the body when exposed to a radio frequency (RF) electromagnetic field. It is defined as the power absorbed per mass of tissue and has units of watts per kilogram. More information is also found in the following reference: Jianming Jin (1998). *"Electromagnetic Analysis and Design in Magnetic Resonance Imaging",* CRC Press. pp. §5.3.3 pp. 226ff. ISBN 978-0849396939. This document is hereby incorporated by reference in its entirety. SAR is

usually averaged either over the whole body, or over a small sample volume (typically 1 g or 10 g of tissue). The value cited is then the maximum level measured in the body part studied over the stated volume or mass. It can be calculated from the electric field within the tissue as with the formula given in Fig. 3. In this formula parameter "σ" is the sample electrical conductivity, parameter 'E " is the RMS electric field, and parameter *"p"* is the sample density.

SAR is used to measure exposure to fields between 100 kHz and 10 GHz. More information is found in the following document: http://www.icnirp.org/documents/emfgdl.pdf . This document is hereby incorporated by reference in its entirety. It is commonly used to measure power absorbed from mobile phones and during MRI scans. The value will depend heavily on the geometry of the part of the body that is exposed to the RF energy, and on the exact location and geometry of the RF source. Thus tests must be made with each specific source, such as a mobile phone model, and at the intended position of use. For example, when measuring the SAR due to a mobile phone the phone is placed at the head in a talk position. The SAR value is then measured at the location that has the highest absorption rate in the entire head, which in the case of a mobile phone is often as close to the phone's antenna as possible. Various governments have defined safety limits for exposure to RF energy produced by mobile devices that mainly exposes the head or a limb for the RF energy:

- United States: the FCC requires that phones sold have a SAR level at or below 1.6 watts per kilogram (W/kg) taken over a volume of 1 gram of tissue.
- European Union: CENELEC specify SAR limits within the EU, following IEC standards. For mobile phones, and other such hand-held devices, the SAR limit is 2 W/kg averaged over 10 g of tissue (IEC 62209-1).

The standards mentioned above are hereby incorporated by reference in their entirety.

Figs. 4a to 4d illustrate different embodiments of the method and consumer device in accordance with the invention. Fig. 4a illustrates the specific absorption rate SAR versus time t to which a user is exposed when using a display device in accordance with a first scenario, which scenario could be referred to as safe usage. In a first time period DL1 (first download time period) the user downloads a book. In this time period the user is exposed to radiation such that the SAR may exceed the predefined exposure limit EXL (this is not always the case, but may happen). In a subsequent second time period RD1 (first read time period) the user reads the book. Such reading period RD1 (several hours) takes typically much longer than the download period DL1 (typically a few minutes). This has been illustrated in the figure by the broken axis. The first read time period RD1 is followed by a second download time period DL2 in which a second book is

downloaded. The second download time period DL2 is followed by a second read time period RD2. In the method of the invention an indicator is determined which is indicative for the SAR. In this example the indicator is indicative for an average SAR AV1 , wherein the average AV1 is a so-called moving average. In Fig. 4a the moving average AV1 increases during the download time periods DL1 , DL2 and decreases during the read time periods RD1 , RD2. What is important to notice is that in this safe usage of the display device the moving average remains below the predefined exposure limit EXL. The size of the window for the moving average may be fixed (in accordance with safety standards that will be made in future) or determined by the user. The same is true for the exposure limit EXL. It may be fixed in accordance with predefined safety standards or it may be set by the user.

Obviously, the quantity of interest in the invention is the radiation to which the user is exposed. Nevertheless, it may be difficult to obtain precise figures for this radiation (SAR). If that is the case an approximation of the SAR may suffice. What is important is that in any case an indicator is determined which is indicative for the SAR. It may be proportional to the SAR or it may be related to a maximum level of the SAR when the antenna is active and assume a constant level during such active time period. It is also possible to build in a safety margin within the indicator such that it can be assured that the SAR is always below the predefined exposure limit independent of the user scenario.

Fig. 4b illustrates the specific absorption rate SAR versus time t to which the user is exposed when using the display device in accordance with a second scenario, which scenario could be referred to as unsafe usage. In this scenario the user has decided to download multiple books in a sequence (or maybe even simultaneously). This is the scenario where the method and consumer device of the invention intervene. In Fig. 4b there is shown three consecutive download time periods DL1 , DL2, DL3. It is also shown that the respective moving average AV2 in this case exceeds the predefined exposure limit EXL during the third download time period. In an embodiment of the invention the communication is disabled (for example by disabling the antenna 95) at the moment DSBL that this occurs. Obviously, it may also be decided to disable the communication at a different moment in time, for example earlier. For example this may be at an earlier moment where the respective moving average AV2 has approached the exposure limit EXL to within a predefined distance.

In any case, in Fig. 4b the invention intervenes in operational use such that the predefined exposure level EXL is not exceeded. In Fig. 4b this occurs abruptly, which may be inconvenient for the user (in particular when the third download is rendered useless because of the interruption). More user-friendly options exist and have been illustrated by way of example embodiments in Figs. 4c and 4d.

In Fig. 4b there is also visualized another aspect of the invention, namely that once the communication has been disabled a certain cool-down time period CD is forced during which the user is prevented from downloading further books. The length of such cool-down time period CD may be prescribed or may be specified by the user. Obviously, the read may still be allowed to use such cool-down time as a read time period RD. The length of the cool-down time period CD may also be made dependent on the height of the predefined exposure limit EXL. For example, a higher exposure limit may cause a longer cool-down time CD. Nevertheless, many variants are possible here.

In Fig. 4c the method of the invention provides for additional functionality, namely prediction functionality. This figure will be discussed in as far as it differs from Fig. 4b. During download it is estimated whether the predefined exposure limit will be exceeded, based upon a current activity. When such exceeding is expected, such as in the case of the third download time period DL3 in Fig. 4c, the communication is controlled such that communication power of the antenna is reduced. Communication power depends on bit rate, but also on the antenna signal that is used. In an embodiment reducing the communication power will result in a slower connection, i.e. it will take a longer time period DL3' before the download completes. In Fig. 4c this has been illustrated by a SAR in the third download time period DL3' with a lower peak as a result of which the respective moving average AV3 will increase with a smaller slope. The latter having the result that in the scenario of Fig. 4c the predefined exposure limit EXL is not exceeded during the third download time period DL3'. In the figure the moment CTRL at which the method controls the communication to a lower communication power level is visualized by the bend in the moving average. In this case the control moment CTRL is exactly at the start of the third download time period DL3', but this is not essential and may also be carried out during such time period in accordance with other embodiments.

Fig. 4d illustrates a further embodiment of the method. This figure will be discussed in as far as it differs from Fig. 4c. Instead of reducing the communication power as soon as the predefined exposure limit is predicted to be exceeded, the third download action is postponed with a predefined delay time DT. Such delay time DT effectively acts as some sort of cool-down period, because the respective moving average AV4 reduces during this time period. This delay time DT may also be used to as a read time period RD. Because of this cool-down effect the respective moving average AV4 remains below the predefined exposure limit EXL during the third download time period DL3.

What can be deduced from Figs. 4a to 4d is that in all embodiments of the invention the communication is controlled such that the prescribed exposure limit is not exceeded. Many variations in controlling the communication are possible and have been discussed in the introductory part of this description. For example, the indicator may be a

simple timer which counts up when the antenna 95 is active and which counts down when the antenna 95 is inactive.

It must be stressed the graphs in Figs. 4a to 4d are purely schematically and only serve to illustrate the principle of the invention in accordance with different embodiments. Radiation levels may deviate as well as the respective time periods. Also, the moving averages AV1 , AV2, AV3, AV4 have been drawn purely schematically. Also, the number of the download time period at which the invention intervenes has been arbitrarily chosen. This number depends on many parameters, such as antenna power, consumer device position on the user, the length of the download time period, actual bit rate, etc.

Fig. 5 illustrates implementation aspects of an embodiment of the method in accordance with the invention. The figure illustrates a software implementation of the method of the invention on a display device as illustrated in Fig. 2. The software is run on the processor 60 and the processor communicates with the wireless transmitter/antenna module 90/95. Within the processor the invention has been be implemented as full software SW. Within the wireless transmitter/antenna module 90/95 it is a combination of software SW and hardware HW. However, this is not essential for the invention any mixture of software and hardware may be chosen. In the example of Fig. 5 the transmitter/antenna module 90/95 has an additional communication port, which is a debug port. This debug port is advantageously used for the purpose of the invention. In the processor 60 there is user software USRS (such as web software and book software for example) which communicates with the transmitter/antenna module via a connection manager CM and a point-to-point protocol (PPP) network PPPN. The invention has been implemented as SAR monitoring software SSW that runs in parallel with the PPPN network, i.e. it receives the same commands as the PPP network PPPN from the connection manager CM. Furthermore, the monitoring software SSW receives logs from the transmitter/antenna module 90/95 which comprise information about the communication power and the bit-rate of the communication. In other words, the monitoring software SSW knows when communication is going on (i.e. it is started by the connection manager CM), and what is being transmitted or received by the antenna. In this example embodiment it is used that the emitted/received radiation is indicative for the radiation to which the user is exposed, i.e. the SAR. The monitoring software SSW determines the indicator (such as a moving average of the emitted radiation) that is indicative for the SAR to which the user is exposed and takes appropriate action (switch off antenna 95, delay download, reduce communication power of the antenna 95) whenever this indicator is expected to exceed the predefined exposure limit EXL.

It must be noted that in Fig. 5 the invention could have been fully implemented within the wireless transmitter/antenna module 90/95. Such module with the additional functionality may be sold as separate entity. Such entity is considered to fall within the scope of the invention as claimed.

Fig. 6 diagrammatically shows a cross-section of a few display elements of an electrophoretic matrix display panel 1, i.e. an example of a bi-stable display panel device 50. The display panel 1 comprises a base substrate 2, an electrophoretic film with an electronic ink which is present between two transparent substrates 3 and 4 which, for example, are of polyethylene. The substrate 3 is provided with transparent picture electrodes 5, 5' and the other substrate 4 with a transparent common electrode 6. The electronic ink comprises multiple micro capsules 7, of about 10 to 50 microns. Each micro capsule 7 comprises positively charged white particles 8 and negatively charged black particles 9. The particles 8 and 9 are suspended in a fluid. The dashed material 29 is a polymeric binder. The layer 3 is not necessary and could alternatively be a glue layer. When a negative voltage is applied to the common electrode 6 with respect to the picture electrodes 5, an electric field is generated which moves the white particles 8 to the side of the micro capsule 7 directed to the common electrode 6 and the display element will appear white to a viewer. Simultaneously, the black particles 9 move to the opposite side of the microcapsule 7 where they are hidden to the viewer. By applying a positive field between the common electrode 6 and the picture electrodes 5, the black particles 9 move to the side of the micro capsule 7 directed to the common electrode 6 and the display element will appear dark to a viewer (not shown). When the electric field is removed the particles 7 remain in the acquired state and the display exhibits a bi-stable character and consumes substantially no power. Instead of white and black the particles may have any desired color.

Fig. 7 shows diagrammatically an equivalent circuit of the matrix display device 1 which comprises an electrophoretic film laminated on the base substrate 2 provided with active switching elements 19, a row driver 16 and a column driver 10. For the second driver circuit 45 and the border region 55 similar techniques can be used as for the first driver circuit 40 and the display region 50. Preferably, the common electrode 6 is provided on the film comprising the encapsulated electrophoretic ink. Alternatively, the common electrode 6 could be provided on a base substrate if the operation of the display is based on in-plane electric fields. The display panel 1 is driven by active switching elements, for example, thin film transistors 19. The display device 1 comprises a matrix of display elements at the area of intersecting row or select electrodes 17 and column or data electrodes 11. The row driver 16 consecutively selects the row electrodes 17, while a column driver 10 provides data signals to the column electrodes 11 for the selected row

electrode 17. Preferably, a processor 15 firstly processes incoming data 13 into the data signals to be supplied by the column electrodes 11.

The drive lines 12 carry signals which control the mutual synchronization between the column driver 10 and the row driver 16. Select signals VG from the row driver 16 which are electrically connected to the row electrodes 17 select the pixel electrodes 22 via the gate electrodes 20 of the thin film transistors 19. The source electrodes 21 of the thin film transistors 19 are electrically connected to the column electrodes 11. A data signal VD present at the column electrode 11 is transferred to the pixel electrode 22 of the display element 18 (also referred to as pixel) coupled to the drain electrode of the TFT if the associated TFT is conductive. In the embodiment shown, the display device of Fig. 1 further comprises an additional capacitor 23 at the location of each display element 18. This additional capacitor 23 is connected between the pixel electrodes 22 of the associated pixel 18 and one or more storage capacitor lines 24. Instead of a TFT other switching elements can be applied such as diodes, MIM's, etc.

The common electrode 6 receives the voltage VB from a backplane driver 25. The backplane driver 25 supplies a sequence of voltages comprising non-zero voltages. The column driver 10 and the row driver 16 may be commonly used drivers. The processor 15 provides control signals 26 to the backplane driver 25 to coordinate the operation of the backplane driver 25 with the column driver 10 and the row driver 16.

If applicable, the processor 15 may comprise a memory 80 for storing previous drive voltages of the pixels 18 required for a transition drive scheme. Alternatively, the memory 80 may be used to store the levels of the correction pulses required for each optical state.

Various variations of the method and consumer device in accordance with the invention are possible and do not depart from the scope of the invention as claimed.

The invention thus provides a method of operating a consumer device 100 having a wireless transmitter 90 for communicating with an external device through an antenna 95, the consumer device 100 being operated by a user, the method comprising: i) communicating with the external device through the antenna 95, ii) determining an indicator that is indicative for a specific absorption rate SAR of the user during operational use of the consumer device 100 to obtain a determined indicator AV1 , AV2, AV3, AV4, wherein the specific absorption rate SAR is a measure of a rate at which energy is absorbed by a body of the user, and iii) controlling the communicating according to the determined indicator AV1 , AV2, AV3, AV4 to prevent the indicator to exceed a predefined exposure limit EXL. The invention also provides a computer program product comprising instructions for causing a processor to perform such method. The invention further

provides a consumer device configured for carrying out such method. The method and the consumer device in accordance with the invention provide for a reduced SAR of the user of the consumer device.

The invention may be applied in various application areas. For example, the invention may be applied in E-paper applications, electronic readers/writers, laptops, PDA's, hand-held, multimedia players, cell phones, etc. The invention is particularly useful in the field of portable devices which are held close to a user's body in operational use.

It will be appreciated that the invention also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of source code, object code, a code intermediate source and object code such as partially compiled form, or in any other form suitable for use in the implementation of the method according to the invention. It will also be appreciated that such a program may have many different architectural designs. For example, a program code implementing the functionality of the method or system according to the invention may be subdivided into one or more subroutines. Many different ways to distribute the functionality among these subroutines will be apparent to the skilled person. The subroutines may be stored together in one executable file to form a self-contained program. Such an executable file may comprise computer executable instructions, for example processor instructions and/or interpreter instructions (e.g. Java interpreter instructions). Alternatively, one or more or all of the subroutines may be stored in at least one external library file and linked with a main program either statically or dynamically, e.g. at run-time. The main program contains at least one call to at least one of the subroutines. Also, the subroutines may comprise function calls to each other. An embodiment relating to a computer program product comprises computer executable instructions corresponding to each of the processing steps of at least one of the methods set forth. These instructions may be subdivided into subroutines and/or be stored in one or more files that may be linked statically or dynamically. Another embodiment relating to a computer program product comprises computer executable instructions corresponding to each of the means of at least one of the systems and/or products set forth. These instructions may be subdivided into subroutines and/or be stored in one or more files that may be linked statically or dynamically.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an"

preceding an element does not exclude the presence of a plurality of such elements. The invention may be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Throughout the Figures, similar or corresponding features are indicated by same reference numerals or labels.

CLAIMS:

1. A method of operating a consumer device (100) having a wireless transmitter (90) for communicating with an external device through an antenna (95), the consumer device (100) being operated by a user, the method comprising:

- communicating with the external device through the antenna (95),
- determining an indicator that is indicative for a specific absorption rate (SAR) of the user during operational use of the consumer device (100) to obtain a determined indicator (AV1, AV2, AV3, AV4), wherein the specific absorption rate (SAR) is a measure of a rate at which energy is absorbed by a body of the user, and
- controlling the communicating according to the determined indicator (AV1, AV2, AV3, AV4) to prevent the indicator to exceed a predefined exposure limit (EXL).

2. The method as claimed in claim 1, wherein the communicating with external device through an antenna is activated by the user.

3. The method as claimed in claim 1 or 2, wherein the controlling of the communicating according to the determined indicator comprises disabling the communicating once the indicator (AV1, AV2, AV3, AV4) has exceeded a predefined exposure limit (EXL).

4. The method as claimed in claim 1, 2 or 3, wherein the controlling of the communicating according to the determined indicator comprises reducing communicating power of the antenna (95) once the indicator (AV1, AV2, AV3, AV4) is within a predefined distance from the predefined exposure limit (EXL).

5. The method as claimed in claim 4, wherein the communication power is reduced by reducing communication bandwidth or by reducing an antenna signal.

6. The method as claimed in any one of the preceding claims, wherein the controlling of the communicating according to the determined indicator (AV1, AV2, AV3, AV4) comprises estimating remaining communication time and determining if the predefined exposure limit (EXL) is to be exceeded within this remaining communication time, the controlling further comprises taking an appropriate measure to prevent the predefined exposure limit (EXL) to be exceeded.

7. The method as claimed in claim 6, wherein the appropriate measure comprises postponing further communication with a predefined delay time (DT) such that the predefined exposure limit (EXL) is no longer expected to be exceeded within the remaining communication time.

8. The method as claimed in any one of the preceding claims, wherein the controlling comprises disabling the wireless transmitter (90).

9. The method as claimed in any one of the preceding claims, wherein the determining of the indicator (AV1, AV2, AV3, AV4) comprises taking a time-average of the specific absorption rate (SAR) during operational use of the consumer device (100).

10. The method as claimed in claim 9, wherein the taking of the time-average comprises averaging the specific absorption rate (SAR) over a time-window with a predefined length.

11. The method as claimed in claim 10, wherein the predefined length of time-window is specified by the user.

12. The method as claimed in any one of the preceding claims, wherein the determining of the indicator (AV1, AV2, AV3, AV4) comprises:

- measuring RF power received by a sensor placed on or near a body part of the user to obtain a measured RF power, and
- determining the indicator (AV1, AV2, AV3, AV4) from the measured RF power.

13. The method as claimed in any one of the preceding claims, wherein the determining of the indicator (AV1, AV2, AV3, AV4) comprises:

- monitoring RF power emitted by the antenna (95) to obtain an emitted RF power, and
- determining the indicator (AV1, AV2, AV3, AV4) from the emitted RF power.

14. The method as claimed in claim 13, wherein the determining of the indicator comprises:

- obtaining an estimate of the specific absorption rate (SAR) from a user-absorption model stored in the consumer device (100), wherein the human-absorption

model comprises information about the relation between RF power emitted by the antenna (95) and the specific absorption rate (SAR) given a specific use of the consumer device (100).

15. The method as claimed in any one of the preceding claims, further comprising: re-enabling the communicating once a cool-down period (CD) has lapsed starting from the disabling of the wireless transmitter (90).

16. The method as claimed in claim 15, wherein the re-enabling comprises re-enabling the wireless transmitter (90).

17. The method as claimed in claim 15 and 16, wherein the length of the cool-down period (CD) is determined by the predefined exposure limit (EXL).

18. The method as claimed in any one of the preceding claims, wherein the predefined exposure limit (EXL) is specified by the user.

19. The method as claimed in any one of the preceding claims, wherein the predefined exposure limit (EXL) is chosen to comply with safety standards.

20. A computer program product comprising instructions for causing a processor to perform the method as claimed in any one of the preceding claims.

21. A consumer device configured for carrying out the method as claimed in any one of claims 1 to 19.

22. The consumer device as claimed in claim 21, comprising a display device for displaying an electronic document.

23. The consumer device as claimed in claim 22, wherein the display device comprises the wireless transmitter (90) and a microprocessor (60), the microprocessor (60) being configured for carrying out the method as claimed in any one of the claims 1 to 19.

24. The consumer device as claimed in claim 23, wherein the display device comprises a display panel (50) selected from a group comprising: an LCD display panel, a bi-stable LCD display panel, an electrowetting display panel, a bi-stable electrowetting

display panel, and an electrophoretic display panel.

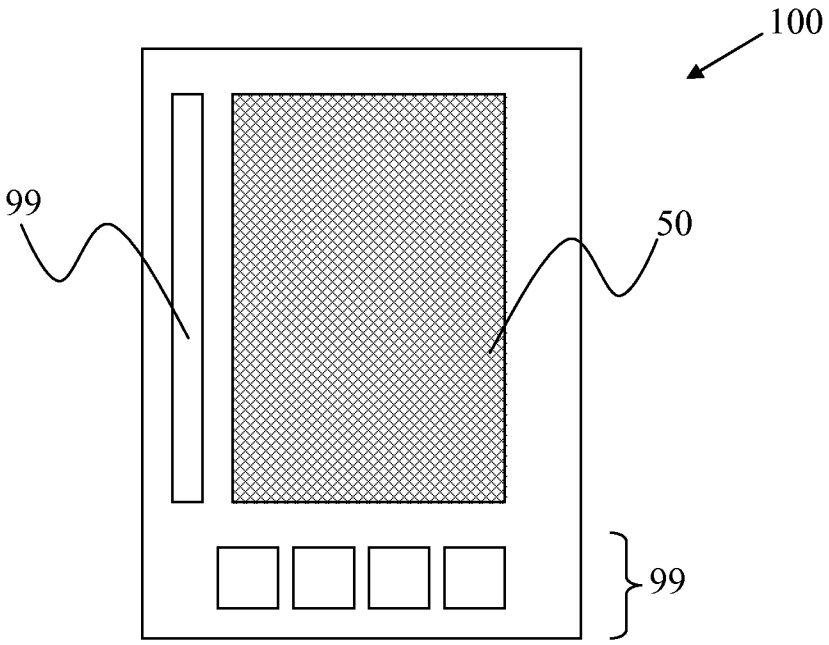

Fig. 1

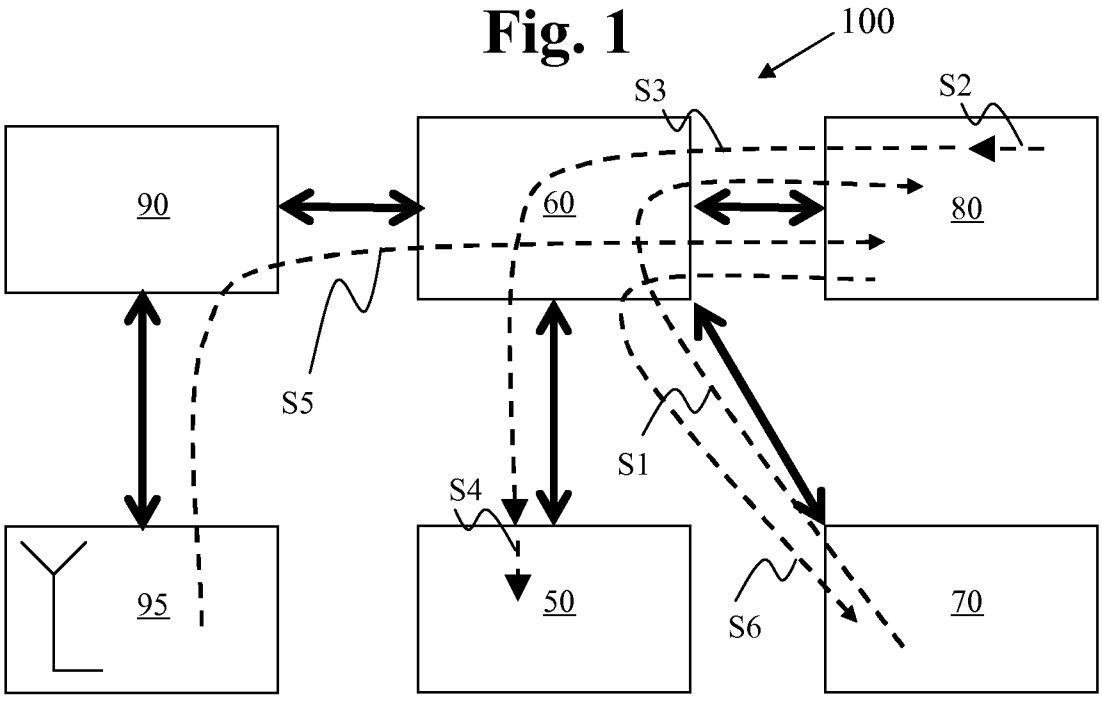

Fig. 2

$$SAR = \frac{\sigma E^2}{\rho}$$

Fig. 3

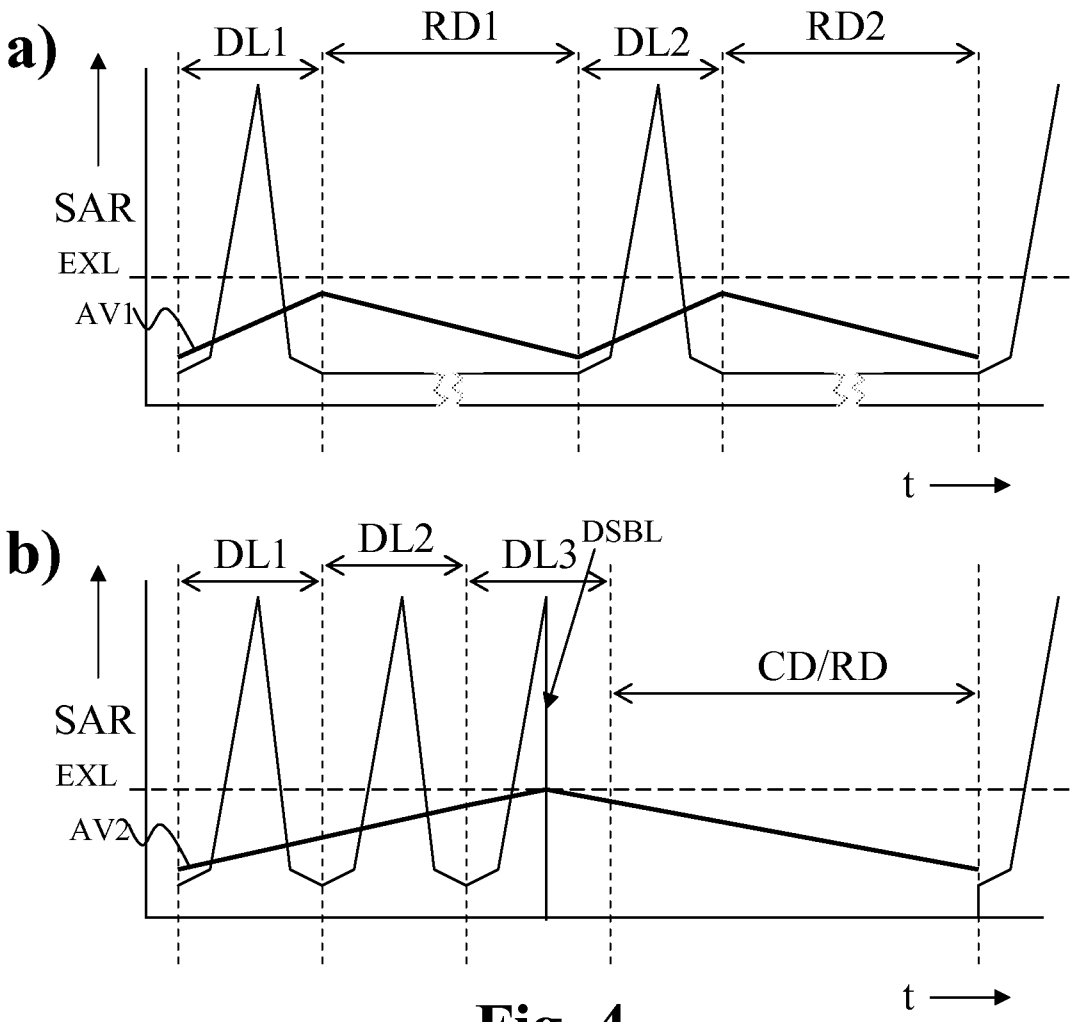

Fig. 4

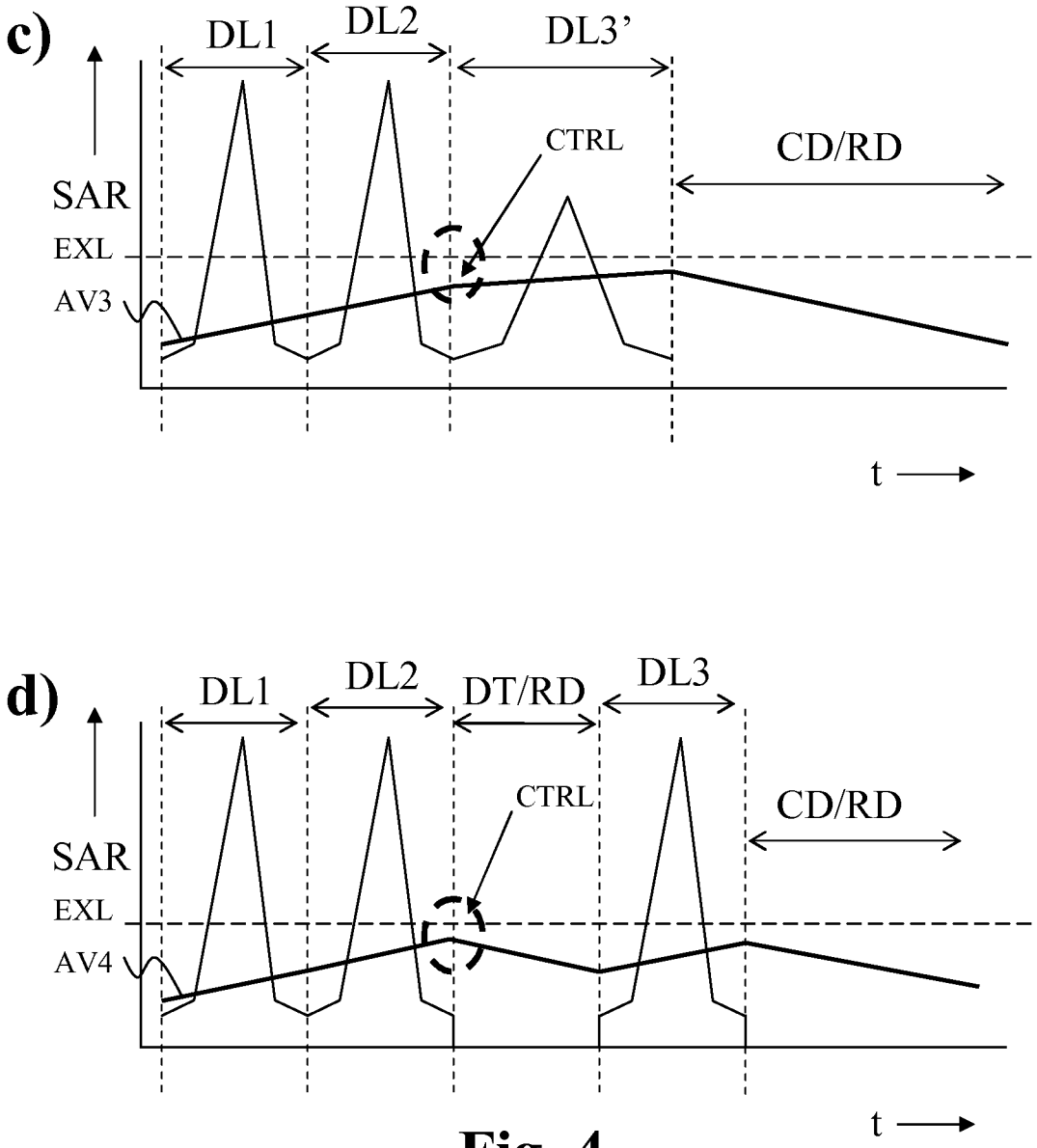
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Fig. 4

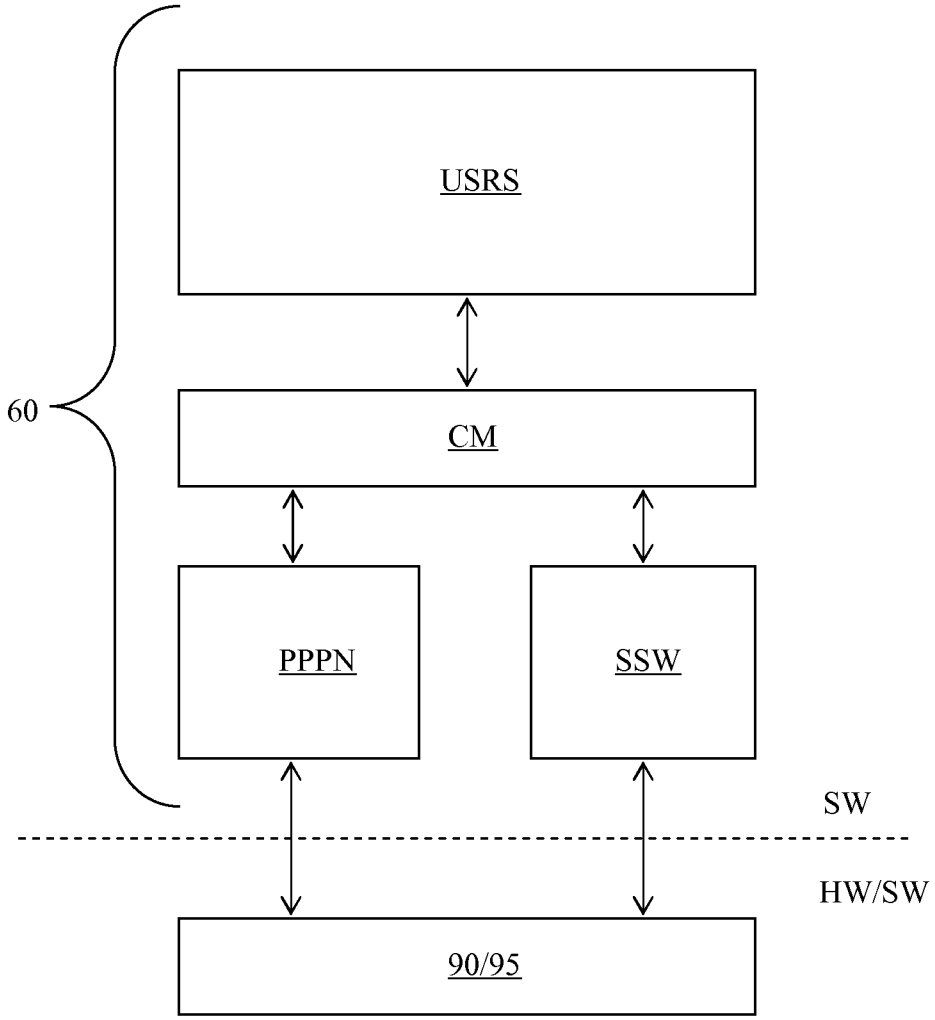

Fig. 5

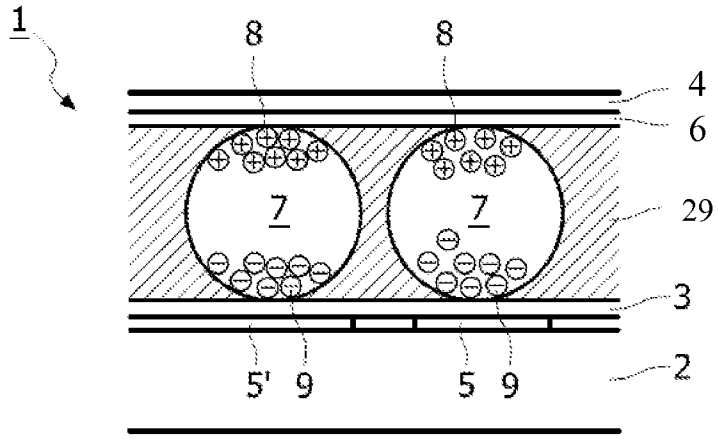
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Fig. 6

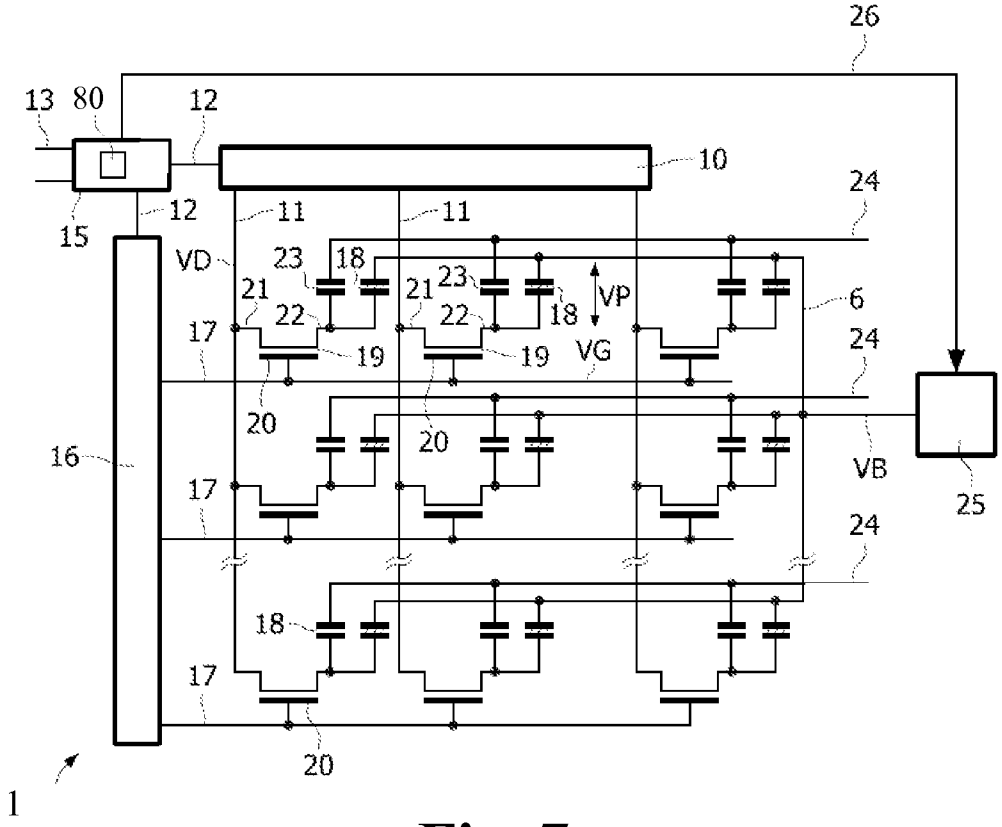
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Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/067364

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B1/38 H01Q1/24
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04B H01Q G01R H04W

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2002/167930 Al (PEARL NORMAN [CA]) 14 November 2002 (2002-11-14) paragraph [0007] - paragraph [0011] ; figures 2a, 2b	1-24
X	W0 95/03549 Al (QUALC0MM INC [US]) 2 February 1995 (1995-02-02) page 1, line 25 - page 2, line 9; figure 2	1-24
X	US 6 134 423 A (WI EDEMAN ROBERT A [US] ET AL) 17 October 2000 (2000-10-17) col umn 1, line 52 - col umn 2, line 37 col umn 11, line 26 - col umn 12, line 56	1-24

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such docu¬ments, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 March 2011	25/03/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Li ndberg, Per

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/067364

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