Abstract: A power supply device and system have an electrically polarized element in which a remnant electrical polarization is formed and retained. Electrodes are formed on the electrically polarized elements and the remnant electrical polarization generates an electrical potential on the electrodes. Electrical circuits are coupled to the electrically polarized element to control the external electric charges attracted and distributed on the electrodes, for establishing the electrical potential on the electrodes. The electrodes can output electric currents by controlling the external electric charges distribution. The electrically polarized element may be made of ferroelectric material, including a ferroelectric bulk ceramic, ferroelectric multilayer ceramic, ferroelectric single crystal, ferroelectric thin film, ferroelectric thick film and ferroelectric polymer, and all the other materials with electric polarization retained therein. Power supply devices and systems made according to the present invention have very long standby time, small in size and efficient for many applications including RF systems.
POWER SUPPLY DEVICE AND SYSTEM

FIELD OF THE INVENTION

The present invention relates to a power supply device and system. In particular, it relates to a power supply device and system that provide electric power with long energy storage and/or long energy standby time.

BACKGROUND OF THE INVENTION

Conventional electric power supply devices and systems, such as batteries, fuel cells, solar cells, are used to provide stable and continuous electric power for a variety of electrical devices. These batteries or fuel cells usually involve converting chemical energy or light energy into electrical energy, and are indispensable in many portable electronic circuit applications. These types of power supplies however suffer from short storage life spans due to high electric leakage. Thus they do not have a long standby time without being recharged or replaced. In addition, the physical sizes of these types of batteries are difficult to be miniaturized, and the costs are relatively high due to their delicate internal structures.

For electric energy storage, capacitors are also not suitable to store energy for a long time due to electric leakage. As such, conventional batteries, fuel cells and capacitors are not preferred for some applications by which long energy standby time is needed, such as portable Radio Frequency Identification (RFID) devices, particularly those used for tamper indicating electric seals. The attachment of a conventional battery particularly does not make sense for RFID tags used for tamper indicating electric seals, in which low but long standby power is utilized only temporarily for transmitting the RF signals, sometimes once in life.

No currently available power supply device or system is suitable for such temporal, low power supply but with long standby time. The continuing success in
RFID systems and applications is being limited by the lack of efficient and appropriate power supply device.

Many energy harvesting mechanisms have been explored for RF systems and applications, including devices and systems capable of converting optical, magnetic, thermal, and mechanical energy into electricity. However, these types of energy conversion devices and systems have relatively complicated structures. In addition, these types of devices and systems are not suitable for use in applications where no other type of energy source is available. For example, a mechanical source is not available for a stationary object, an optical source is not available for items stored in the dark, etc. This is particularly the case in which, RF tags are to be used for tamper indicating electric seals.
SUMMARY OF THE INVENTION

Embodiments of the present invention provide a power supply device and system for applications that demand long standby time and miniature physical size, such as portable RF systems, RF-ID tags, particularly for tamper indicating electric seals.

According to one aspect, a power supply device according to embodiment of the present invention has an electrically polarized element in which an electrical polarization is retained. Electrodes are formed on surfaces of the electrically polarized elements, and the electrical polarization generates an electrical potential on the electrodes. Electrical circuits may be coupled to the electrically polarized element to control the external electric charges attracted and distributed on the electrodes, accompanied by changing the electrical potential on the electrodes. By controlling the external electric charges distribution, the electrodes can output electric currents. The electrically polarized element may be made of ferroelectric material, including a ferroelectric bulk ceramic, ferroelectric multilayer ceramic, ferroelectric single crystal, ferroelectric thin film, ferroelectric thick film and ferroelectric polymer, or any other materials with electric polarization retained therein. Compared to conventional power supply devices, the power supply devices and systems made according to the present invention have very long energy storage time and standby time, small in size and suitable for supplying electric powers to many applications including RF systems.
BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects and advantages of the present invention will be described in detail with reference to the accompanying drawings, in which:

Fig. 1 is a schematic diagram showing a power supply device according to one embodiment of the present invention;

Fig. 2 is a schematic diagram showing a power supply device according to another embodiment of the present invention;

Figs. 3, 4 and 5 are schematic diagrams showing power supply devices according to various further embodiments of the present invention;

Figs. 6A, 6B and 6C are schematic diagrams showing power supply devices according to embodiments of the present invention when coupled to various types of electronic circuits;

Fig. 7 is a chart showing experimental results of samples prepared according to embodiment showing in Fig 3;

Fig. 8 is a schematic diagram showing an RFID system according to embodiments of the present invention;

Fig. 9 is a chart showing further experimental results of samples prepared according to another embodiment as shown in Fig 3 but with the orientation of the diode reversed.
DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to embodiments of the present invention, electric polarization existing in elements with structural and electric asymmetry is utilized for electric power supply. For the purpose of illustration, ferroelectric material is used as an example of the electrically polarized element, to describe power supply devices and systems according to embodiments of the present invention. However, it should be appreciated that the present invention is not limited to power devices and systems made of ferroelectric material. Other materials with similar properties, e.g. with the center of positive charge not completely overlapping the center of negative charge, may well be suitable for making the power devices, in a manner similar to ferroelectric materials. These other materials may include, for example, quartz, ZnO, AlN, etc.

Taking the ferroelectric material as an example, ferroelectricity is defined as a physical phenomenon in which a spontaneous electric polarization exists in a material (i.e., ferroelectric material), and the electric polarization in the material (ferroelectric element) can be re-oriented from one direction to another, by an external electric field applied thereto. The reorientation process involves two or more domain states within the crystal (or within individual grains in a ceramic material). Upon polarization, net positive charges are present in the ferroelectric element adjacent to one surface, and net negative charges are present adjacent to the opposite surface.

On the surfaces of the ferroelectric element, external electric charges will be collected to screen the polarization inside the element, due to the remnant electrical polarization generated from the polarized ferroelectric element. The power supply mechanism according to embodiments of the present invention is to control the distribution of the surface charges collected on the surfaces of the polarized ferroelectric element.
Reference is now made to Fig. 1, which shows a power supply device 100 according to one embodiment of the present invention. Device 100 includes an electrically polarized element, for example an electrically polarized ferroelectric element 110, with an electric polarization formed inside. In the present embodiment, electrically polarized ferroelectric element 110 has a remnant electrical polarization 111 formed inside the element after the element is electrically poled. The electric poling is a process in which an external electric field is applied to a ferroelectric element, to force the electric dipoles and domains of the ferroelectric element to reorient along with the external electric field. After the electric poling, at least part of the electric dipoles are reoriented and polarization is retained along the external electric field direction, even after the electric field is removed, resulting in net positive charges 122 and net negative charges 124 being generated inside the ferroelectric element 110. For the purpose of illustration, net positive charges 122 are shown at positions adjacent to bottom surface 112, and net negative charges 124 are shown at positions adjacent to top surface 114, of the electrically polarized ferroelectric element 110.

Ferroelectric element 110 has a bottom electrode 132 and a top electrode 134, formed on bottom and top surfaces 112 and 114, respectively. The remnant electrical polarization 111 is therefore to generate an electric potential on the first and second electrodes 132 and 134.

When placed in an environment having surrounding external electric charges or particles, such as in a normal atmosphere environment, and due to the electrostatic interaction with the remnant polarization in the ferroelectric element 110, negative charges 142 will be attracted on bottom electrode 132, and positive charges 144 will be attracted on top electrode 134, both mainly from surrounding environment. The bottom and top electrodes 132 and 134 may stop attracting external charges when the level of electrostatic charges on both the bottom and top electrodes are balanced.
When the polarized ferroelectric element 110 is electrically connected to a load 10, such as an external electric circuit with a resistor 12 and a capacitor 14 connected in parallel, and when control switch 150 is closed, the electric boundary condition on the bottom and top electrodes 132 and 134 will be changed, resulting in a portion of the negative charges 142 and positive charges 144 flowing through the circuit of load 10. Accordingly, a transient current is supplied to the load 10. An electric power supply device, in this embodiment the electrically polarized ferroelectric element 110 can now supply a transient electric current by coupling to load 10.

Fig. 2 shows a power supply device 200 according to another embodiment of the present invention. Power supply device 200 includes an electrically polarized ferroelectric element 210, having net positive charges 222 generated adjacent to bottom surface 212, and net negative charges 224 generated adjacent to top surface 214. Further, ferroelectric element 210 is structured with bottom and top electrodes 232 and 234 in a manner similar to the ferroelectric element 110 shown in Fig. 1. A remnant electrical polarization 211 in the ferroelectric element 210 is therefore to generate an electric potential on the first and second electrodes 232 and 234.

In the present embodiment, power supply device 200 includes a switch 260 electrically coupled between bottom electrode 232 and top electrode 234. When switch 260 is open, bottom electrode 232 and top electrode 234 attract external opposite electric charges 242 and 244, in a manner similar to that shown in Fig. 1, until a first balance status is reached. Here, the first balance status refers to a situation where, the electric potential generated by the remnant electrical polarization 211 in the ferroelectric element 210 is neutralized by the electric charges 242 and 244 on the bottom electrode 232 and top electrode 234, when the switch 260 is open.

In the stand-by state, switch 260 is firstly closed to form a short-circuit 262 between bottom electrode 232 and top electrode 234. A portion of the external
charges 242 and 244 will then be redistributed through the short-circuit 262, resulting in the first balance status being broken and a second balance status being established. The second balance status refers to a situation where, the electric potential generated by the remnant electrical polarization 211 in the ferroelectric element 210 is neutralized by both the short circuit 262 (when the switch 260 is closed) and a remaining portion of the electric charges 242 and 244 on the bottom electrode 232 and top electrode 234.

When it is desired to supply electric current, the switch 260 is opened to disconnect the short-circuit 262 by which, the second balance status is broken. This will result in the change of electrical potential on the bottom electrode 232 and top electrode 234. Accordingly, a transient current will flow through terminals 252 and 254 connected to bottom and top electrodes 232 and 234, hence the power supply device 200 can now supply electric current to load 20.

Figs. 3 to 5 show power supply systems employing two pieces of electrically polarized ferroelectric elements according to further embodiments of the present invention. The ferroelectric elements in these embodiments are substantially the same as that shown in Fig. 1 and Fig. 2.

In Fig. 3, a power supply system 300 includes two ferroelectric elements 310a and 310b which are coupled to each other via a switch 360. An anode 334a at which net positive charges 324a of first ferroelectric element 310a is generated, is coupled to a cathode 334b at which net negative charges 324b of second ferroelectric element 310b is generated, via a switch 360. Further, a cathode 332a of first ferroelectric element 310a is coupled to an anode 332b of second ferroelectric element 310b. When switch 360 is open, external charges 342a, 344a, 342b, 344b are attracted on respective anode and cathodes, until a first balance status is established. At the first balance status, the electric potential generated by the remnant electrical polarization in the first ferroelectric element 310a is neutralized by the electric charges 342a and 344a on the bottom electrode 332a and top electrode 334a, when switch 360 is open.
For the power supply device 300, switch 360 is firstly closed to connect the second element 310b to the first element 310a. A portion of the external charges 342a and 344a are then redistributed by the connection to the second element 310b, resulting in the first balance status being broken and a second balance status being established. At the second balance status, the electric potential generated by the remnant electrical polarization in the first ferroelectric element 310a is neutralized by both the second element 310b and a remaining portion of the electric charges 342a and 344a on the bottom electrode 332a and top electrode 334a.

When it is desired to supply electric current, the switch 360 is opened to disconnect the second element 310b from the first element 310a and hence the second balance status is broken. This will result in the establishment of an electrical potential on the bottom electrode 332a and top electrode 334a. Accordingly, a transient current will flow through terminals 352 and 354 connected to bottom and top electrodes 332a and 334a, hence the power supply system 300 can now supply electric current to load 30.

In one preferred embodiment, the two ferroelectric elements 310a and 310b are identical.

A power supply system 400 shown in Fig. 4 has a modified configuration based on the power supply system 300 shown in Fig. 3. Two ferroelectric elements 410a and 410b are coupled to each other via two switches 460 and 470, with opposite electrodes coupled to each other. When switches 460 and 470 are open, the electrodes of first ferroelectric element 410a attract external charges on its electrodes, resulting in an establishment of a first balance status in first ferroelectric elements 410a.

For the power supply device 400, both switches 460 and 470 are firstly closed to connect the second element 410b to the first element 410a. A portion of
the external charges of the first element 410a are then redistributed by the
connection to the second element 410b, resulting in the first balance status being broken and a second balance status being established. At the second balance status, the electric potential generated by the remnant electrical polarization in the first ferroelectric element 410a is neutralized by both the second element 410b and a remaining portion of the electric charges on the electrodes of first element 410a.

When it is desired to supply electric current, both switches 460 and 470 are opened to disconnect the second element 410b from the first element 410a and hence, the second balance status is broken. This will result in the establishment of an electrical potential on the electrodes of first element 410a. Accordingly, a transient current will flow through terminals 452 and 454 connected to electrodes of first element 410a, hence the power supply system 400 can now supply electric current to load 40.

In one preferred embodiment, the two ferroelectric elements 410a and 410b are identical.

A power supply system 500 shown in Fig. 5 has a further modified configuration based on the power supply system 300 shown in Fig. 3. Power supply system 500 has two electrically polarized ferroelectric elements 510a and 510b serially coupled to each other, and with top electrode 534a of ferroelectric element 510a physically contacted with bottom electrode 532b of second ferroelectric elements 510b. Bottom electrode 532a of ferroelectric element 510a is electrically coupled to top electrode 534b of second ferroelectric elements 510b, and coupled to a first terminal 552. A second terminal 554 is bonded to electrode 534a.

By having the first and second ferroelectric element 510a and 510b physically contacted to each other at the opposite polarization terminals, external charges are prevented from being attracted to the contact surfaces, i.e. the top
electrode 534a of first ferroelectric element 510a and bottom electrode 532b of second ferroelectric elements 510b will attract significantly less external charges. The reason is that the electric charges of opposite signs near the contact interface can screen each other. When external electric charges 542a and 544b are attracted onto respective electrodes 532a and 532b, the stacked first and second ferroelectric elements 510a and 510b reach a first balance status.

When the first and second ferroelectric elements 510a and 510b are physically separated in an instant, the prior-contacted electrodes 534a and 532b are separated apart, and unscreened net charges near the surfaces are exposed to surrounding environment, resulting in attraction of external charges thereon, and hence causing the first balance status broken. After the separation, terminal 544 is still connected with the top electrode 534a of the first ferroelectric element 510a but disconnected from the bottom electrode 532b of the second ferroelectric element 510b. Electrical charges are then demanded from the load 50, in an attempt to resume the balanced status, and thus a transient current is produced through the load 50.

Power supply systems according to the present embodiments are particularly useful for applications in which a physical displacement is to be detected. In one example, a first polarized ferroelectric element may be attached to one part of a seal, and a second polarized ferroelectric element may be attached to another part of the seal. In another example, the physical displacement of an object is utilized to turn on/off a switch. The first and second polarized elements are then electrically connected according to the manner shown in Fig. 5, or as the switches shown in Figs. 1-4, with an alarm device connected as a load. When the seal is broken or when the switch is triggered, an electric current is generated from the polarized element to supply to the alarm device, which could be an RF transmitter. The broken of the seal or triggering of switch can therefore be detected.
A large variety of electronic circuits may be used together with the power supply devices and systems according to the present invention illustrated, to meet various different applications. For example, diodes, capacitors and/or inductors may be used in a power supply device or system as a filter, a rectifier and/or a temporary electricity reservoir or storage. Instead of the single diode as the rectifier shown in Figures 3, 4 and 5, other configurations of diodes, capacitors and/or inductors may also be used including a full wave rectifier, a voltage doubling circuit (which is a degeneration from the Cockroft-Walton voltage multiplier circuit), or a filter/storage circuit module with an inductor, capacitor and diode, to couple to a power supply device 600, as shown in Figs. 6A, 6B and 6C. One capacitor or plural capacitors can be used as a temporary charge storage circuit to control the transient discharging process or the duration of the current supply.

The power supply device according to an embodiment shown in Fig. 3 is now taken as an example to show experimental results, which has the following properties / parameters:

Ferroelectric materials: Similar ferroelectric lead zirconate titanate (PZT)
ceramic disks: φ 25 x 1 mm; Capacitance: 5.7-5.8 nF; tgδ: 0.003.
Capacitor: 100 nF;
Switch: on/off single pole switch;
Resistor: Three distinct values of 100 KΩ, 1 MΩ and 10 MΩ;
Diode: Schottky barrier, 1N4148 or equivalent.

An oscilloscope is used to record the data/waveform obtained. In this case, this waveform represents the transient voltage curve with respect to time in the RC load. Fig. 7 shows the experimental results obtained through the measurements. The three curves in Fig. 7 correspond to the three distinct current demands simulated experimentally by different resistance values, which curves 710, 720 and 730 corresponds to the 100 KΩ resistor, 1 MΩ resistor and 10 MΩ resistor, respectively. With rising electrical current corresponding to a smaller
resistance load, the faster the energy depletes, thus leading to falling voltage output more quickly. The discharge voltage typically peaks within a range from 0.60 to 0.75 V as measured after the diode, with a maximum peak current at 7.5 µA for the 100 KΩ load. The duration (considered from 90% to 10%) varies from 8 milli-second (msec) to less than 0.2 msec depending on the load. The peak power is about 5.6 µW for a 100 kΩ load; the peak power is about 0.36 µW for a 1 MΩ load.

It is observed that the temporal power is provided repetitively by switching the switch 360 on and off. The three curves in Fig 7 are also obtained from the same pair of the ferroelectric elements without any re-poling process between the three tests.

Further results of this can be seen in Fig. 9, where a discharge peak voltage of 2.5 V and a maximum power output of 62 µW for a 100 kΩ load is achieved using another two ferroelectric lead zirconate titanate disks. The result is obtained with the embodiment as shown in Fig 3, except that the orientation of the diode is reversed. This power can be used for many varied electronic applications, and is sufficient for RF signal transmission.

It should be appreciated by a person skilled in the art that although only bulk ferroelectric ceramic disks are used in the construction of this system, other materials with remnant electric polarization can also be used in power supply devices and systems according to the present invention. Examples of these other types of suitable materials includes, but not limited to, ferroelectric single crystals, ferroelectric composites, ferroelectric thin and thick films, ferroelectric multilayer materials, ferroelectric polymers, and all the other materials with electric polarizations.

Fig. 8 shows an RFID system 800 employing a power supply device or system according to one embodiment of the present invention. As an application example, a power supply device or system according to embodiments of the
present invention is used to supply power to a low power RFID transmitter 812. The RFID transmitter 812 can emit pre-recorded signals through an antenna 810 to a predetermined receiver (not shown). With the temporal power supply device 818 coupled to the RFID transmitter 812 optionally through a rectifier 816, a filter and storage circuit 814, the RF signal emission is simultaneously triggered. Conceptually, the RF emission module design is substantially the same as that of the existing portable RF systems, but the power supply device 818 replaces the conventional energy sources, including various batteries, solar cells, or any other prior known power scavenging mechanisms.

In one application, the temporal power system as disclosed herein is also applicable for RFID systems particular for tamper indicating electronic seal. The long standby time, simple structure, and low cost of the present invention is particularly useful for RFID applications for tamper indicating electric seal.

Although embodiments of the present invention have been illustrated in conjunction with the accompanying drawings and described in the foregoing detailed description, it should be appreciated that the invention is not limited to the embodiments disclosed, and is capable of numerous rearrangements, modifications, alternatives and substitutions without departing from the spirit of the invention as set forth and recited by the following claims.
CLAIMS

1. A power supply device comprising:
   a first electrically polarized element having an electrical polarization;
   wherein the electrical polarization is to induce electric charges on the
   first electrically polarized element; and
   wherein the power supply device is to supply electric power upon
   variation of the induced electric charges.

2. The power supply device as recited in claim 1, wherein the first electrically
   polarized element includes:
   a first electrode formed on a first surface; and
   a second electrode formed on a second surface, wherein said second
   surface is on an opposite side of the electrically polarized element from said first
   surface, and wherein the electrical polarization is to induce electric charges on the
   first and second electrodes.

3. The power supply device as recited in claim 2, further comprising:
   a circuit coupled to the first electrode and the second electrode, wherein
   the circuit is switchable between a first connection to establish a balance status of
   the electric charges on the first and second electrodes, and a second connection
   to break the balance status to establish an electrical potential on the first and
   second electrodes.

4. The power supply device as recited in claim 3, wherein one of the first and
   second connections is a short circuit connection.

5. The power supply device as recited in claim 3, wherein one of the first and
   second connections is an open circuit.
6. The power supply device as recited in claim 3, wherein the electric potential is established on the first and second electrodes when the circuit couples the first and second electrodes to a load.

7. The power supply device as recited in claim 3, wherein the circuit includes:
a switch coupled between the first and second electrodes, wherein closing the switch forms a short-circuit between the first and second electrodes to establish a balance status of the electric charges on the first and second electrodes, and opening the switch breaks the balance status to establish the electrical potential.

8. The power supply device as recited in claim 3 further comprising:
a second electrically polarized element to coupled to the first electrically polarized element, wherein coupling of the second element to the first element establishes a balance status of the electric charges on the first and second electrodes of the first electrically polarized element, and decoupling of the second electrically polarized element from the first electrically polarized element breaks the balance status to establish the electrical potential.

9. The power supply device as recited in claim 8, wherein each electrode of the second electrically polarized element is coupled to an electrode of the first electrically polarized element having an opposite polarity to establish the balance status.

10. The power supply device as recited in claim 9, further comprising:
a contact interface formed by an electrode of the second electrically polarized element being in physical contact with an electrode of the first electrically polarized element having an opposite polarity to reduce attraction of external electrical charges at the electrodes in physical contact, and wherein separation of the electrodes in physical contact establishes the electrical potential.
11. The power supply device as recited in claim 9, wherein each of the electrodes of the second electrically polarized element are decoupled from the electrodes of the first electrically polarized element to establish the electrical potential.

12. The power supply device as recited in claim 8, wherein the first electrically polarized element and the second electrically polarized element are identical.

13. The power supply device as recited in claim 1, wherein the first electrically polarized element is an electrically polarized ferroelectric element.

14. The power supply device as recited in claim 13, wherein the electrically polarized ferroelectric element is a material selected from the group consisting of a ferroelectric bulk ceramic, ferroelectric multilayer ceramic, ferroelectric single crystal, ferroelectric thin film, ferroelectric thick film and ferroelectric polymer.

15. The power supply device as recited in claim 13, wherein the electrically polarized ferroelectric element has a remnant polarization to induce the electric charges.

16. A power supply system comprising a plurality of power supply devices as recited in claim 1.

17. The power supply device as recited in claim 1, further including:
   a current filter circuit coupled to the first electrically polarized element, wherein the current filter circuit supplies a filtered current.

18. The power supply device as recited in claim 1, further including:
   a current rectifier circuit coupled to the first electrically polarized element, wherein the current rectifier circuit supplies a rectified current.

19. The power supply device as recited in claim 1, further including:
a temporary charge storage circuit coupled to the first electrically polarized element, wherein the temporary charge storage circuit supplies a current over a controlled duration.

20. An RF system comprising an RF device and a power supply device that is coupled to the RF device and supplies current to the RF device, wherein the power supply device is a power supply device recited in claim 1.

21. An RF system as recited in claim 20, wherein the electric power from the power supply device is used for emitting a RF signal.

22. A method for supplying power to a load comprising:
   - inducing charges on a first electrode formed on a first surface of a first electrically polarized element and a second electrode formed on a second surface of the first electrically polarized element, wherein said second surface is on an opposite side of the electrically polarized element from said first surface; and
   - switching a circuit connecting the first and second electrodes between a first connection to establish a balance status of the electric charges on the first and second electrodes, and a second connection to break the balance status to establish an electrical potential on the first and second electrodes.
**FIG. 7**

Voltage (V) vs. Time (μsec)

- □: load 1
- ●: load 2
- △: load 3

**FIG. 8**

Diagram showing components labeled 800, 810, 812, 814, 816, and 818.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

H02J 15/00 (2006.0 1)  H02J 11/00 (2006.0 1)

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)

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 practicable, search terms used)

DWPI, TXTUSO, TXTUS1, TXTUS2, TXTUS3, TXTEPI, TXTGBl, TXTWO 1, TXTAU1: power supply, polarization, charge, electrode, electrostatic, generate and similar terms.

c. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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D Further documents are listed in the continuation of Box C

See patent family annex

* Special categories of cited documents:
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“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 documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search 10 December 2007

Date of mailing of the international search report 13 DEC 2007

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustralia.gov.au
Facsimile No. +61 2 6283 7999

Authorized officer

ANISH SINGH
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No: (02) 6283 7915

Form PCT/ISA/210 (second sheet) (April 2007)
This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX