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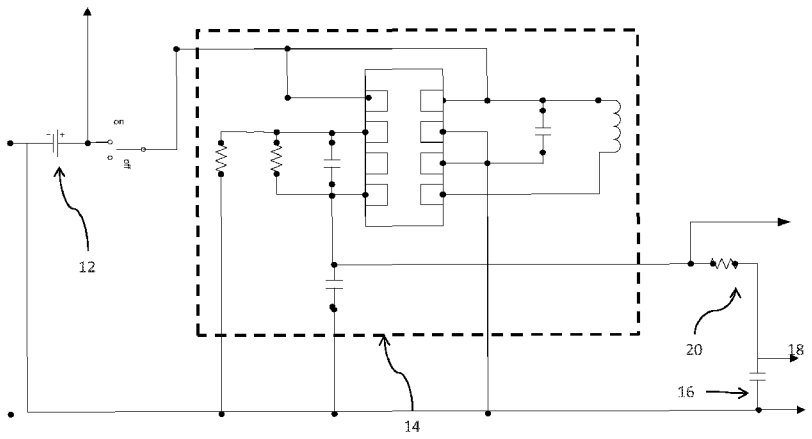


Fig. 3

(57) Abstract: A system is provided for extending the shelf life capacity of a coin cell, the system utilizing a coin cell; a voltage step up converter/regulator, configured to step up the voltage of output from the coin cell and the storage capacitor; and a storage capacitor receiving output from the voltage step up converter/regulator.

WO 2011/127376 A2

METHOD OF EXTENDING THE SHELF-LIFE OF A COIN CELL IN AN APPLICATION REQUIRING HIGH PULSE CURRENT

Inventors:

Paul O'Sullivan

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/322,013, filed April 8, 2010. This application is herein incorporated by reference in its entirety for all purposes.

STATEMENT OF GOVERNMENT INTEREST

[0002] The invention was made with United States Government support under Contract No. W31P4Q-06-C-0330 awarded by the Navy. The United States Government has certain rights in this invention.

FIELD OF THE INVENTION

[0003] The invention relates to a method of extending the shelf-life of a coin cell in an application requiring high pulse current.

BACKGROUND OF THE INVENTION

[0004] A coin cell provides an attractive, low-cost and volume-efficient energy source solution for a firing circuit for a miniature electro-explosive device (EED). In this application, the ability to fire the EED reliably after a long shelf-life period measured in years, with a high degree of reliability, is desired. At the end of this shelf-life period, the coin cell is required to charge a capacitor quickly, resulting in a high pulse current load on the

coin cell. A coin cell chemistry such as lithium poly carbon monofluoride [Li(CF)n] is well-suited in many respects for this application since it has a long shelf-life with a very low internal self-discharge rate. However, in applications such as this, the coin cell also powers the control circuitry which generally requires that the voltage remain above a threshold voltage for proper operation during this pulse loading of the coin cell. The coin cell output voltage is a function of the pulse current load and the internal impedance of the coin cell. Not much information exists in published literature on the effect of shelf life on the internal impedance of these coin cells, but testing after exposure to high temperature diurnal cycling (-38 C to 70 C) for a period of 30 days showed some degradation in the internal impedance.

[0005] Because of volume constraints, simply using a larger coin cell with a higher discharge rate capability (and thus a lower internal impedance) is not a feasible solution in this application. In addition, it is desired that the solution should be low-cost.

[0006] What is needed, therefore, are techniques to accommodate this degradation and extend the shelf-life capability of the coin cell.

SUMMARY OF THE INVENTION

[0007] One embodiment of the present invention provides a system for extending the shelf life capacity of a coin cell, the system comprising: a coin cell; a voltage step up converter/regulator, configured to step up the voltage of output from the coin cell; a storage capacitor receiving output from the voltage step up converter; and a firing circuit disposed on the storage capacitor.

[0008] Another embodiment of the present invention provides such a system further comprising a resistor disposed between the voltage step up converter and the storage capacitor.

[0009] A further embodiment of the present invention provides such a system wherein the converter/regulator is a boost regulator.

[0010] Still another embodiment of the present invention provides such a system wherein the converter/regulator is a regulator with output voltage that is higher than input voltage and high efficiency at low power levels.

[0011] One embodiment of the present invention provides a method for extension of a shelf life of a coin cell powered firing circuit; operating a coin cell at a low voltage; using a converter to boost voltage from the coin cell; and boosting and regulating the voltage above a threshold voltage of the firing circuit.

[0012] Another embodiment of the present invention provides such a method further comprising storing the voltage in a storage capacitor.

[0013] A further embodiment of the present invention provides such a the method further comprising filtering the voltage with a storage capacitor resistor.

[0014] The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and not to limit the scope of the inventive subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] **Figure 1** is a graph of performance of a known coin cell without a converter.

[0016] **Figure 2** is a block diagram illustrating a converter regulator configured in **accorda**nce with one embodiment of the present invention.

[0017] **Figure 3** is a circuit diagram illustrating a converter implementation configured in accordance with one embodiment of the present invention.

[0018] **Figure 4** is a graph of performance of a known coin cell with a converter configured according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0019] In one embodiment of the present invention a system **10** is provided for extending the shelf life capacity of a coin cell, the system having: a coin cell **12**, a voltage step up converter/regulator **14**, configured to step up the voltage output from the coin cell **12**, and a storage capacitor **16** and a firing circuit (not shown, path to circuit is identified with ref No. **18)** disposed on the output side of the voltage step up regulator.

[0020] Testing of coin cells show that the coin cell internal impedance decreases with increasing current loads within limits. As illustrated in **Figure 1**, a graph of coin cell power output in the absence of a converter/ regulator, increased power is available when the output is loaded to a point where the cell output voltage is substantially below 50% of its open circuit voltage (50% of the

open circuit voltage being the point where a cell with a constant source impedance would deliver maximum power to the load).The coin cell can provide increased power output at higher current loads, albeit at a reduced output voltage.

[0021] One embodiment of the present invention takes advantage of this fact by adding a converter/regulator **14** between the output of the coin cell **12**, and the firing-control circuit **18** and with a storage capacitor charging resistor **20**, and is shown in block diagram form in **Figure 2**. In one embodiment, the converter/regulator **14** is a boost regulator. The boost regulator of such an embodiment is selected as it can develop an output voltage that is higher than the input voltage with high efficiency at low power levels, and it is small and inexpensive. The converter/regulator **14** provides a constant voltage to the storage capacitor charging resistor **20** and the firing control circuit **18** (above the required threshold), while operating the coin cell **12** at a low enough voltage to provide the required output power. By making use of a converter **14** with a low starting voltage and high efficiency, this circuit **10** allows for proper operation at lower voltage output at the coin cell. In such an embodiment, the circuit **10** can tolerate a greater degradation in the internal impedance of the coin cell, thereby extending the shelf life of the coin cell. The implementation of one embodiment of the present invention illustrated in Figure **3** was tested with Panasonic and Rayovac BR1632 coin cells; sample test results with Rayovac BR 1632 cell are shown in **Figure 4**. One skilled in the art will appreciate that alternative coin cells could be used.

[0022] One embodiment of the present invention provides a system for extending the shelf life capacity of a coin cell, the system comprising: a coin cell **12**; a voltage step up converter/regulator **14**, configured to step up the voltage of output from the coin cell **12**; the storage capacitor **16** receiving output

from the voltage step up converter**14**; and a firing circuit **18** disposed on the output side of the voltage step up regulator**14**. In such an embodiment, a resistor **20** can be disposed between the voltage step up converter**14** and the storage capacitor**16**.In one such embodiment, the converter/regulator **14** is a boost regulator. In others it may be a regulator with output voltage that is higher than input voltage and high efficiency at low power levels.

[0023] One embodiment of the present invention provides a method for extension of a shelf life of a coin cell powered firing circuit; operating a coin cell at a low voltage; using a converter to boost voltage from the coin cell; and boosting and regulating the voltage above a threshold voltage of the firing circuit. Such a method may further comprise storing the voltage in a storage capacitor or filtering the voltage with a storage capacitor resistor.

[0024] The foregoing description of the embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of this disclosure. It is intended that the scope of the invention be limited not by this detailed description, but rather by the claims appended hereto.

CLAIMS

What is claimed is:

1. A system for extending the shelf life capacity of a coin cell, the system comprising:

a coin cell;

a voltage step up converter/regulator, configured to step up the voltage of output from said coin cell; and

a storage capacitor receiving output from said voltage step up converter/regulator.

and a firing circuit disposed on the output side of said storage capacitor.

2. The system according to claim 1 further comprising a resistor disposed between said voltage step up converter/ regulator and said storage capacitor.

3. The system according to claim 1 wherein said voltage step up converter/regulator is a boost regulator.

4. The system according to claim 1 wherein said voltage step up converter/regulator is a regulator with output voltage that is higher than input voltage and high efficiency at low power levels.

5. A method for extension of a shelf life of a coin cell powered firing circuit;

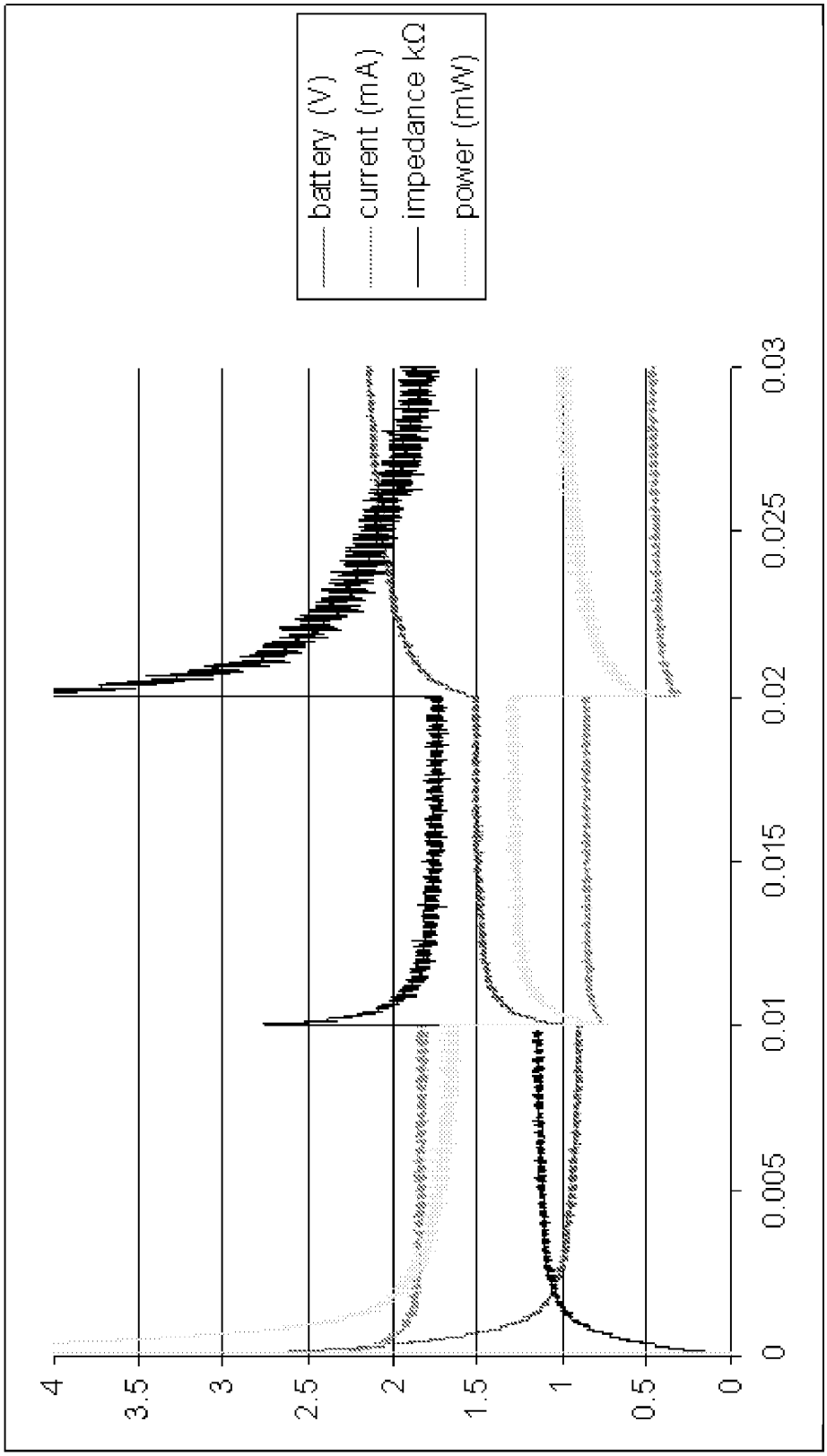
operating a coin cell at a low voltage;

using a converter to boost voltage from said coin cell; and

boosting and regulating said voltage above a threshold voltage of said firing circuit.

6. The method of claim 6 further comprising storing said voltage in a storage capacitor.

7. The method of claim 5, said method further comprising filtering said voltage with a storage capacitor resistor.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current (mA)
impedance kΩ
power (mW)
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3.5
3
2.5
2
1.5
1
0.5
0
0
0.005
0.01
0.015
0.02
0.025
0.03

Fig. 1

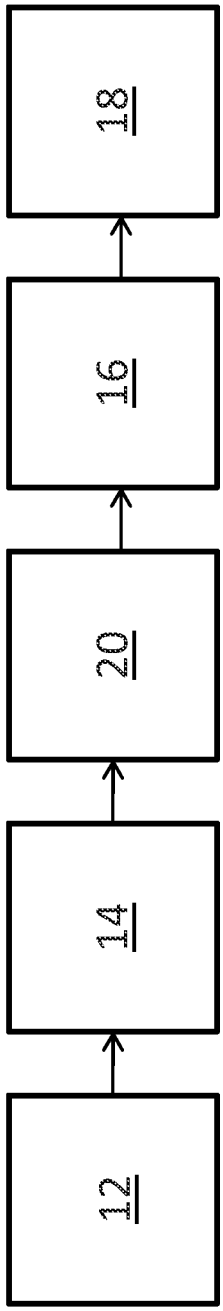


Fig. 2

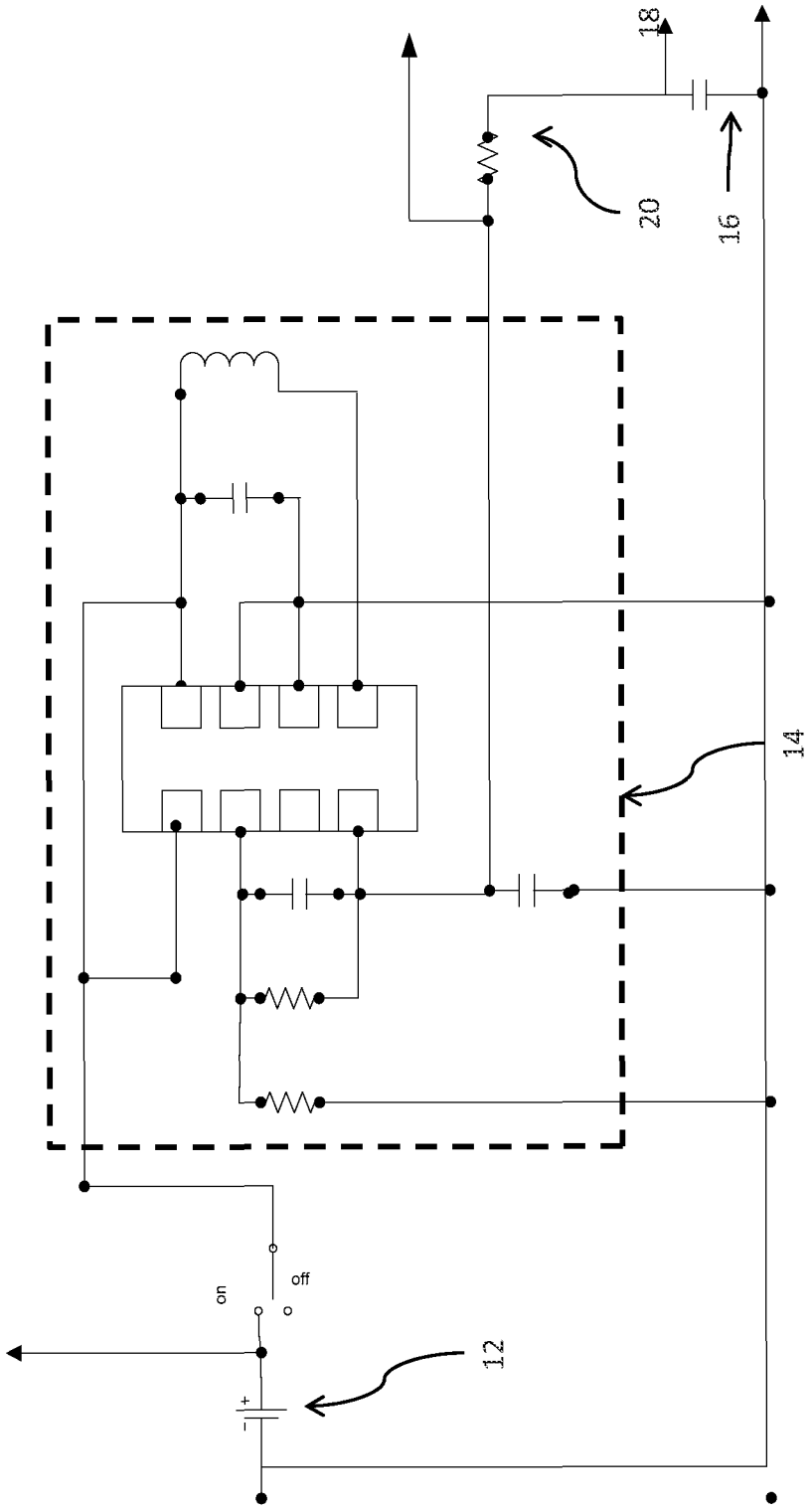
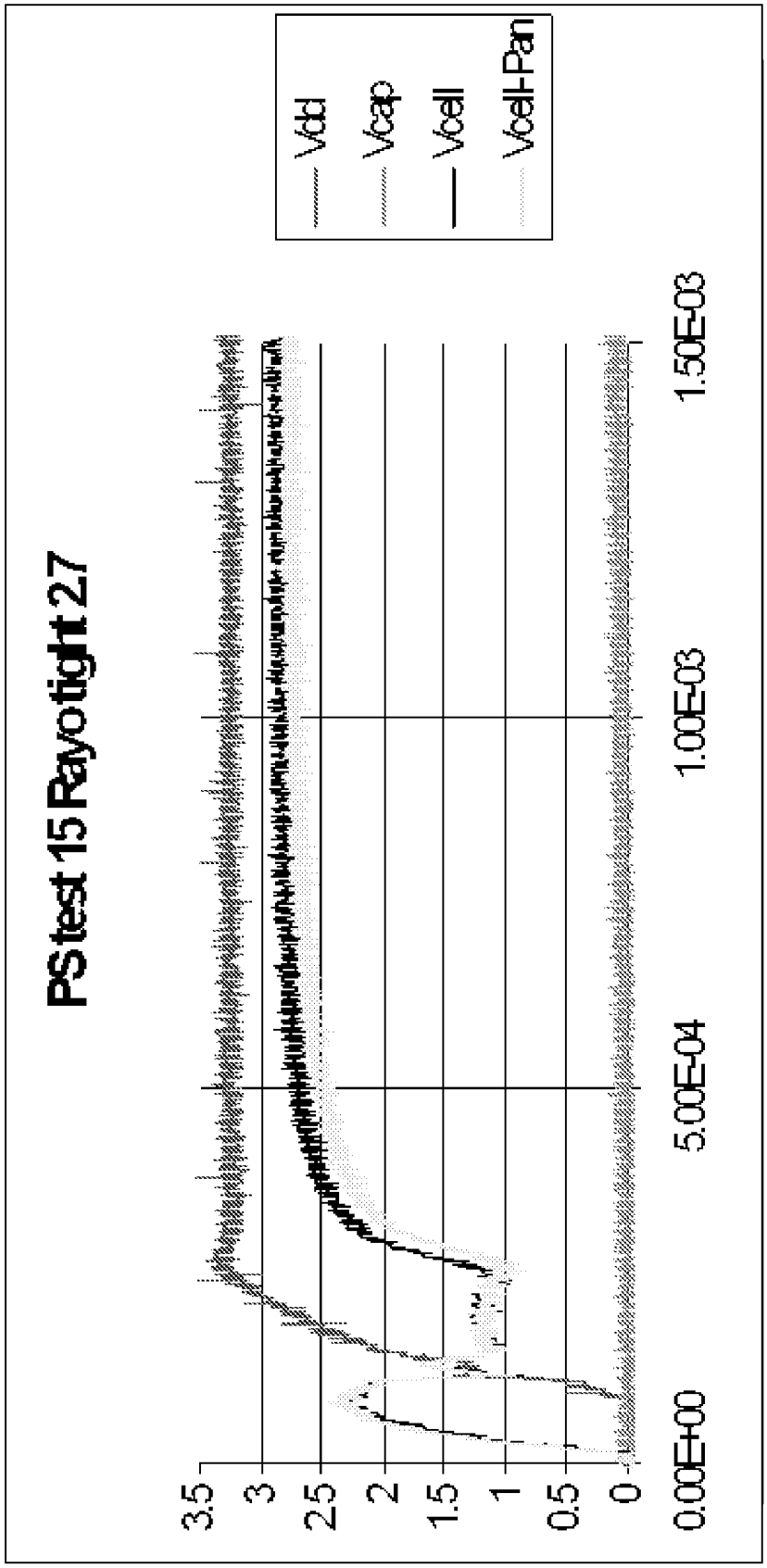


Fig. 3


PS test 15 Rayotight 27
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Vcap
Vcell
Vcell-Pan
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3
2.5
2
1.5
1
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0
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1.50E-03

Fig. 4