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[Continued on next page]

(54) Title: ADAPTIVE RECTIFIER DEVICE FOR TAPPING UBIQUITOUS RADIO WAVES

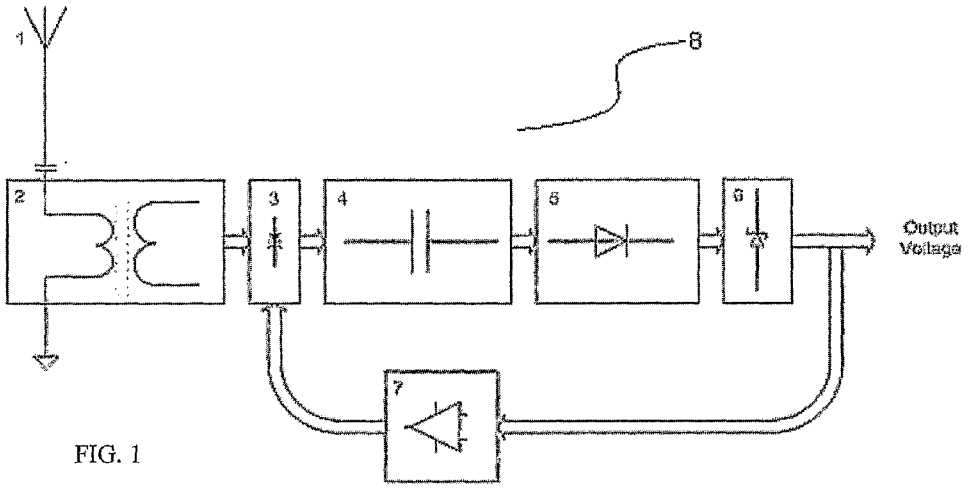

FIG. 1

(57) Abstract: This invention relates to a device for harvesting energy from ubiquitous radio waves and more particularly an adaptive rectifier device (8) designed as power harvesting circuit which is to harvest electrical energy by tapping the commercially available radio waves. The device (10) comprises of an antenna (1), a high frequency transformer (2), an automatic tuning circuit (3), a capacitors bank (4), a rectifier (5), a threshold limit circuit (6) and an adaptive circuit (7). The threshold limit circuit (6) is configured having a predetermined output voltage and when an output voltage is below than the predetermined voltage, the automatic tuning circuit (3) starts searching for new source of radio frequency (RF) energy by changing its capacitance by feeding a distinctive voltage into the automatic tuning circuit (3) via the adaptive circuit (7). The searching for RF energies stops when the output voltage level resumes to the predetermined voltage.

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ADAPTIVE RECTIFIER DEVICE FOR TAPPING UBIQUITOUS RADIO WAVES

1. TECHNICAL FIELD OF THE INVENTION

This invention relates generally to energy harvesting and more particularly to a circuit capable of converting ubiquitous radio waves into electrical energy, the circuit capable of automatically selecting the strongest wave within the bandwidth.

2. BACKGROUND OF THE INVENTION

Energy harvesting, also known as power harvesting or energy scavenging is a process by which energy is captured and stored. The idea of harvesting otherwise wasted energy is not new, but it's beginning to gain popularity. Not only are researchers hoping to reap the energy from people, but they're also planning to use vibrations from motors and even passing trains to generate power. In some cases, converting mechanical vibrations into a tiny charge may be enough to power a wireless sensor. In others, thousands of footsteps may be require to power lights and audio systems.

A variety of different methods exist for harvesting energy, such as solar power, ocean tides, piezoelectricity, thermoelectricity and physical motion. Traditionally electrical power has been generated from fossil fuels in large, centralized plants. Large-scale ambient energy, such as sun, wind and tides, is widely available but trickier to harvest. In urban areas, there is a surprising amount of electromagnetic energy in the environment as a result of radio and television broadcasting that can be used for energy harvesting.

People have been fascinated by the idea of 'free' energy for hundreds of years, with many scientists and engineers attempting to create perpetual motion

machines, even after the law of Conservation of Energy became generally accepted. Unfortunately, losses due to mechanical friction and air resistance mean that no machine can be built that will continue to operate forever with no need for additional energy after the initial input.

Another view of 'free' energy is renewable energy sources such as solar, wind and wave energy, where the supply is unlimited and no financial payment has to be made to use the energy - even though considerable investment has to be made in suitable energy-harvesting equipment. If only small amounts of energy are required for a given application, several other options are available. For example, self-winding wrist watches have been manufactured for over 80 years, and kinematic powered quartz watches have been on the market for around 20 years. Other electrical and electronic technologies offer additional possibilities.

Passive RFID (radio frequency identification) tags can harvest sufficient energy from the RF reader/writer that they can power an integrated circuit and transmit data to the reader and/or decode and record data on the internal memory. Furthermore, devices using micro-electro-mechanical system (MEMS) technology only require tiny amounts of energy, leading many academic groups to investigate ways to harvest sufficient energy from the environment to provide the necessary power.

One option is to harvest energy from the electromagnetic waves that surround us as a result of radio and television broadcasts, mobile telephone communications, and the electromagnetic fields created by electric currents passing through conductors. This can be made to work provided a large enough collection area can be used and the RF power is high enough – which usually implies the source and receiver have to be close together.

3. SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a device for harvesting energy from ubiquitous radio waves to solve the above mentioned problem.

It is another object of the present invention to provide a device which can automatically searching for available radio frequencies.

Yet, it is another object of the present invention to provide a device which can automatically searching for available radio frequencies when output voltage is below predetermined threshold voltage.

These and other objects of the present invention are achieved by,

An adaptive rectifier device (8) for energy harvesting comprises of :-

an antenna (1), a high frequency transformer (2), an automatic tuning circuit (3), a capacitors bank (4), a rectifier (5) and an adaptive tuning means;

characterized in that

said adaptive tuning means includes a threshold limit circuit (6) and an adaptive circuit (7), said adaptive circuit (7) is adapted to search for next available and strong radio frequency signal for said energy harvesting,

said searching is executed when output from said adaptive rectifier device (8) falls below a threshold set by said threshold limit circuit (6).

Preferably, the threshold limit circuit (6) is set having a predetermined threshold voltage.

More preferably, when output voltage is below than the predetermined threshold voltage, the adaptive circuit (7) will send voltage signal to the automatic tuning circuit (3) to enable changing of capacitance value in a resonance circuit.

More preferably, the resonance circuit includes such high frequency transformer (2) and such automatic tuning circuit (3).

4. BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows energy harvesting system according to the present invention.

FIG. 2 shows commercial FM spectrum of commercial radio frequencies.

5. DETAIL DESCRIPTION OF THE DRAWINGS

Figure 1 shows an adaptive rectifier device (8) for energy harvesting according to the present invention. The device (8) comprises of an antenna (1), a high frequency transformer (2), an automatic tuning circuit (3), a capacitors bank (4), a rectifier (5), a threshold limit circuit (6) and an adaptive circuit (7). For energy harnessing circuit, an adaptive tuning means is critical which has radio frequency (RF) searching capability for a strong wave in a designated bandwidth. A s shown in the figure, the adaptive tuning means comprises of the threshold limit circuit (6) and the adaptive circuit (7).

The threshold limit circuit (6) function is to monitor the output voltage level and the adaptive circuit (7) is to control the automatic tuning circuit (3) for fine-tuning of suitable radio frequencies (RF) the adaptive circuit (7) operates by feeding biasing voltage to the automatic tuning circuit (3). Sufficient output voltage level is required in order to sustain supplies to the operating circuits without interruption, therefore when the output voltage level dropped below the designated threshold limit, automatic tuning circuit (3) starts searching new

source of RF energy by varying its capacitance. This could be performed by controlling the voltage that feeds into the automatic tuning circuit (3) from the adaptive circuit (7). The feeding voltage determines the tuned frequency of the resonance circuit which comprises of the high frequency transformer (2) and the automatic tuning circuit (3). Searching for RF energies stops when the voltage output level resumes to the predetermined output voltage.

Figure 2 shows commercial available FM radio spectrum in Malaysia. The adaptive circuit proposed by the present invention was designed to capture signals within the FM range that is between 88MHz to 108MHz. The figure indicates that the output voltage can be harvested within these available bands is between 72μV to 330μV and it is believed that it is sufficient for further boosting up to 3V and above.

While a particular form of the present invention has been illustrated and described, it will be apparent that many varying embodiments with various modification can be made without departing from the scope of the invention. Therefore, it is understood that the detail herein are to be interpreted as illustrative and not in a limiting sense.

CLAIM

What is claim is

1. An adaptive rectifier device (8) for energy harvesting comprises of :-

an antenna (1), a high frequency transformer (2), an automatic tuning circuit (3), a capacitors bank (4), a rectifier (5) and an adaptive tuning means;

characterized in that

said adaptive tuning means includes a threshold limit circuit (6) and an adaptive circuit (7), said adaptive circuit (7) is adapted to search for next available and strong radio frequency signal for said energy harvesting,

said searching is executed when output from said adaptive rectifier device (8) falls below a threshold set by said threshold limit circuit (6).

2. An adaptive rectifier device (8) for energy harvesting as claimed in Claim 1, further characterized in that said threshold limit circuit (6) is set having predetermined threshold voltage.

3. An adaptive rectifier device (8) for energy harvesting as claimed in Claim 2, further characterized in that if detected output voltage fall below than said predetermined threshold voltage, said adaptive circuit (7) send voltage signal to said automatic tuning circuit (3).

4. An adaptive rectifier device (8) for energy harvesting as claimed in Claim 3, further characterized in that, said automatic tuning circuit (3) when triggered by said voltage signal starts searching for new source of radio

frequency energy by changing its capacitance in the resonance circuit, said resonance circuit comprises of said high frequency transformer (2) and said automatic tuning circuit (3).

5. An adaptive rectifier device (8) for energy harvesting as claimed in Claim 4, further characterized in that said searching for new radio frequency energy stops when output voltage resumes to said predetermined threshold voltage.

6. An adaptive rectifier device (8) for energy harvesting as claimed in Claim 1, further characterized in that said automatic tuning circuit (3) comprises an LC circuit.

7. An adaptive rectifier device (8) for energy harvesting as claimed in Claim 1, further characterized in that said antennae is a wideband antenna for continuous coverage of about 88 MHz to 108 MHz radio frequency spectrum.

8. An adaptive rectifier device (8) for energy harvesting as claimed in Claim 1, further characterized in that said bandwidth is between 88 MHz to 108 MHz radio frequency spectrum.

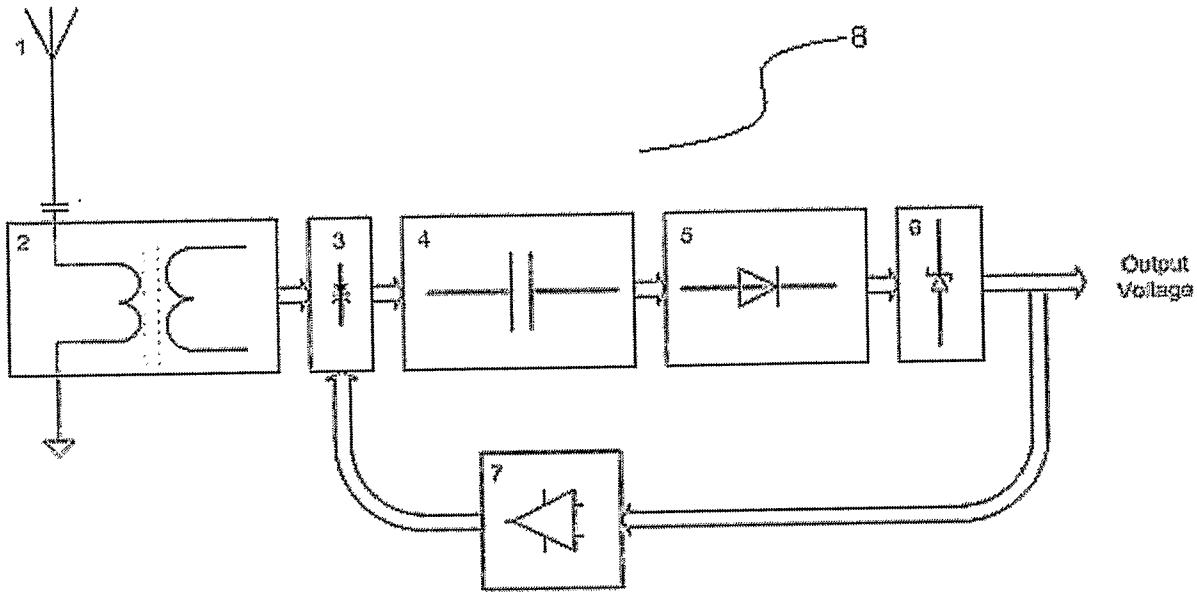
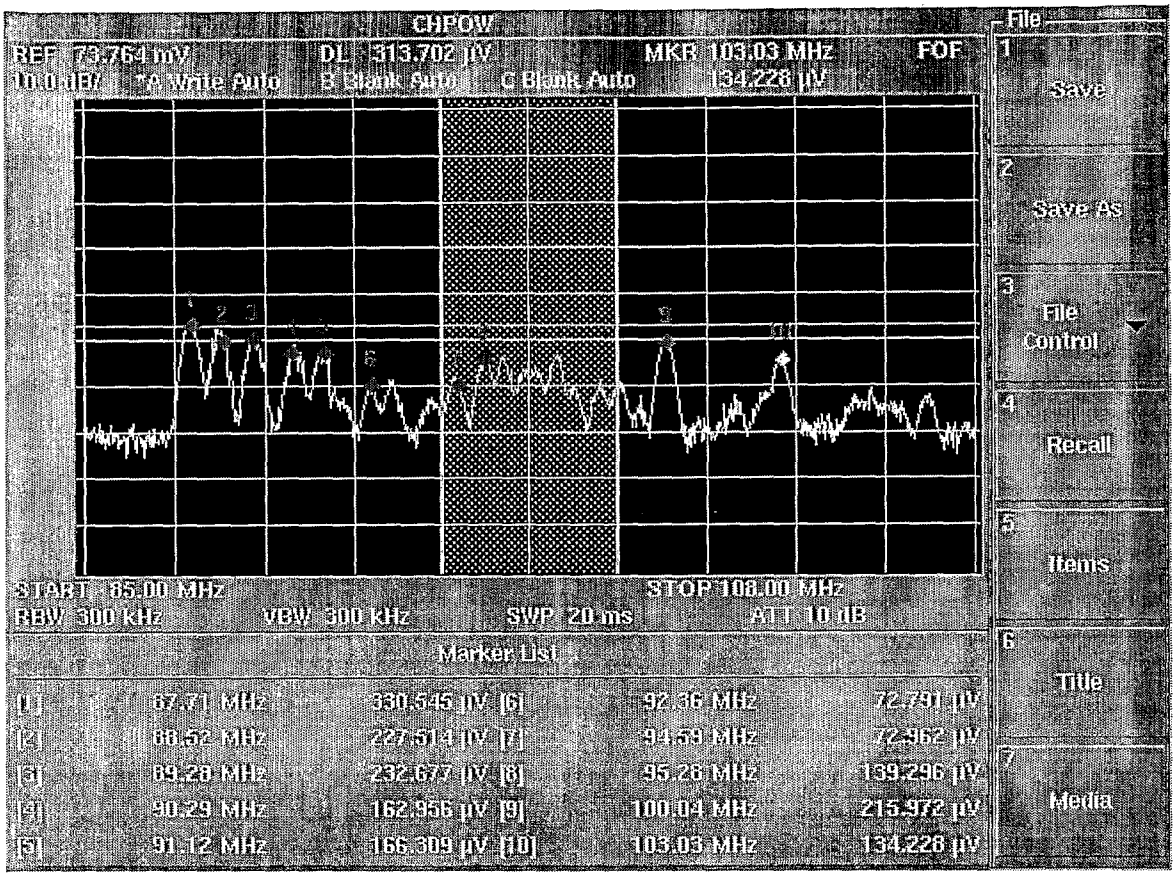


FIG. 1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MKR 103.03 MHz
134.228 µV
FOF
10.0 dB/
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B Blank Auto
C Blank Auto
START 85.00 MHz
STOP 108.00 MHz
RBW 300 kHz
VBW 300 kHz
SWP 20 ms
ATT 10 dB
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[5] 91.12 MHz 166.309 µV [10] 103.03 MHz 134.228 µV
File
1 Save
2 Save As
3 File Control
4 Recall
5 Items
6 Title
7 Media

FIG. 2