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# RAPID DEMAGNETIZATION OF NEODYMIUM MAGNETS DUE TO MECHANICAL SHOCK AS PULSE POWER SUPPLY FOR MICROPROCESSOR SYSTEM

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## ABSTRACT

The chosen aspects of energy recovery (Energy Harvesting) and the unconventional method of electric power generation from mechanical shock in a NdFeB neodymium-magnets based device were presented. The construction of the impulse-activated harvester together with its components was described. Using the system to determine basic magneto-mechanical and electric parameters, the maximum current values generated in the construction were outlined. This work shows use of the magnets in an electric power generators, used as pulse power supply in a microprocessor instant boot system. Generators are based on NdFeB magnet rods and can produce the power of a few watts in a few milliseconds.

**Keywords:** Smart material, neodymium magnets (NdFeB), Pulse power supply

## INTRODUCTION

The main goal of the new electronic technologies is to provide electrical power by use of ambient energy for supplying small electrical and electronic devices or kept this energy for a longer time in ultracapacitors (Wright 2006). This new approach is usually described as Energy Harvesting (EH). Possible sources that can be used for generating „free" energy are: sunlight (including infrared light), wind, different levels of temperature or salinity. In a big city, even the aerial is a source of energy that can be obtained from the electromagnetic waves in its surroundings (so called electromagnetic smog). Recently, there is a lot of research going on in order to work out a new way of obtaining electrical energy for electronic systems supply. In the field of new energy recovering techniques, ones using temperature transformation like heat pump or kinetic energy of a human body are definitely worth mentioning.

The foundation of EH is creating new concepts of voltage generators, that will be using cross effects, including increasingly, magneto-mechanic one. Assuming that even when it comes to small powers or efficiencies, they can still become valuable source of energy. The huge attention has been paid to that issue for the last few years in the biggest research institutes all over the world. The Energy Harvesting concept together with development of energy recovering devices' (harvesters) development belongs to the field of alternative and renewable energy.

Taking into account the speed of harvesters' construction technology development, very soon they can completely replace galvanic cells because of the ecological reasons. According to the fact that harvesters recover energy from the losses, they help obtaining higher values of systems' and devices' efficiencies. The main advantages of the EH devices are: small sizes, mobility, possibility of use in hardly available environments, reduction of the amount of wires; limitation of materials, devices and systems used.

By reason of the physical phenomena occurring during the energy exchange process, their construction, principles of work and environmental conditions in a specified working area, harvesters (as the sources with different electrical characteristics) can be divided into three groups:

- DC voltage harvesters (e.g. harvesters based on the thermoelectric effect),
- AC voltage harvesters (e.g. harvesters based on the Faraday effect or so called piezoelectric patches),
- impulse harvesters (e.g. harvesters with a magnetostrictive core).

In order to design an electrical circuits for harvesters, the knowledge of their working characteristics is mandatory. Only the ones based on the thermoelectric or photovoltaic effect can generate the DC voltage. Those which regain energy from vibrations, magnetostrictive, piezoelectric or based on the Faraday effect are the sources of AC voltage, they were listed in Fig. 1.

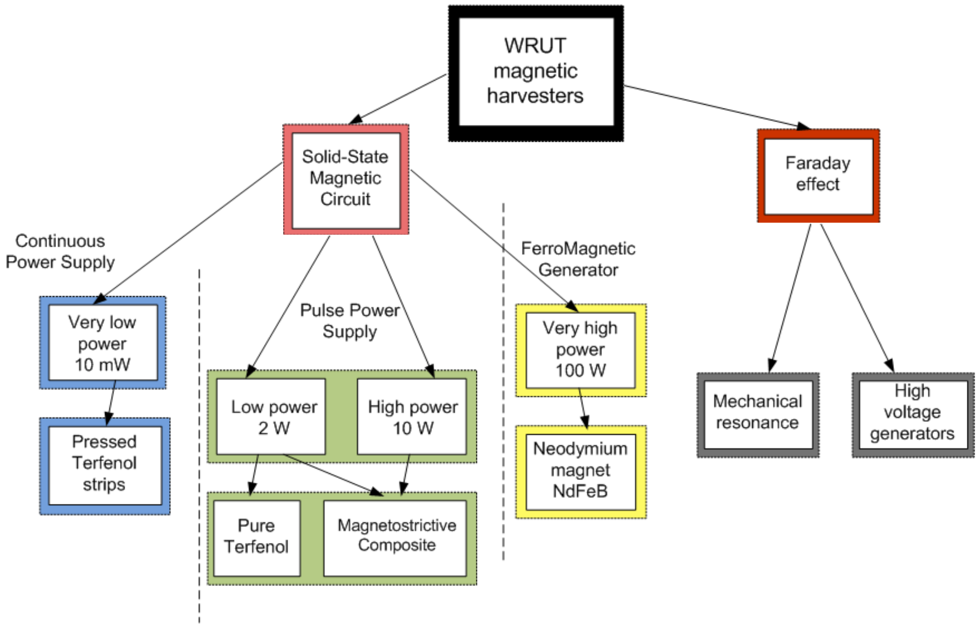


Fig. 1. Structure of evaluating Energy Harvesting methods adopted by the team from the Wroclaw University of Technology (WRUT).

Harvesters which are supplied with the energy from the impacts (Kaleta 2010), are totally different kind. Electric energy generation lasts only for a very short period of time when it comes to the impulse power supply, although its current amplitude is extremely high. Harvesters “supplied” with a mechanical shock, generate various voltage output. However, they are described as the one with strong current impulse and also with additional frequencies, generated in the occurring signal because of the resonance in the core-coil system.

## CONCEPT AND IMPLEMENTATION OF A SHOCK HARVESTER

Current generators of the particular type, are harvesters from the EDFMG (explosive-driven ferromagnetic generators) group that generate the electromagnetic wave, that occurs due to the instant demagnetisation of a magnet caused by a mechanical shock (Lee 2003), that is a result of an explosion or other strong force impulse. In this moment, magnet loses its magnetic properties generating strong impulse magnetic field in its surroundings. During the impact even the total destruction of a magnet is possible, however the amount of energy that is generated on a coil is huge and it is sufficient to charge the high voltage capacitors with substantial capacities.

The new concept of the harvester was worked out, based on the idea of a ferromagnetic generator (FMG), in which the strong magneto-mechanical phenomena occur, including demagnetisation of the strong neodymium NdFeB magnets in order to generate electric current due to the mechanical shock. One of the construction's priorities was to standardize particular sizes and parts so every single element of the harvester could be easily exchanged and disassembled. In the Fig. 2. the harvester's parts were presented.

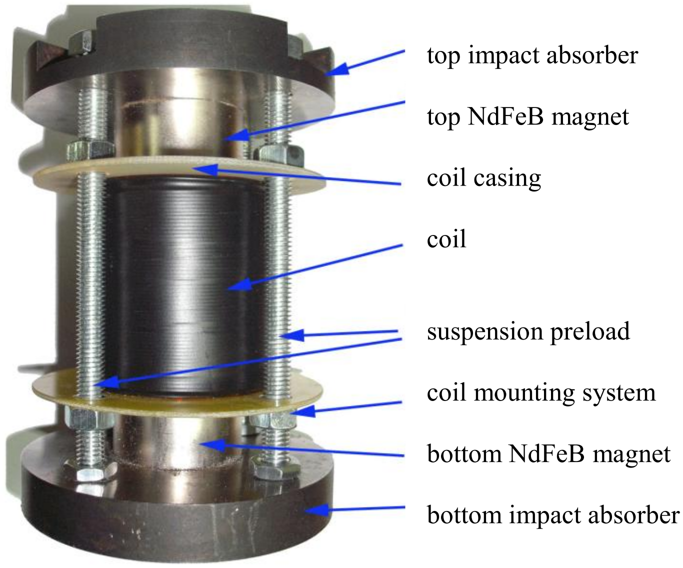


Fig. 2. The view of a shock harvester with the description of its elements.

## DETERMINING THE DYNAMIC PARAMETERS

For the construction of the test stand, the Pico Power Development system was used. It had been already used in Wroclaw University of Technology Dynamic Laboratory so it was delivered with the signal DSP processor (Kaleta 2010).

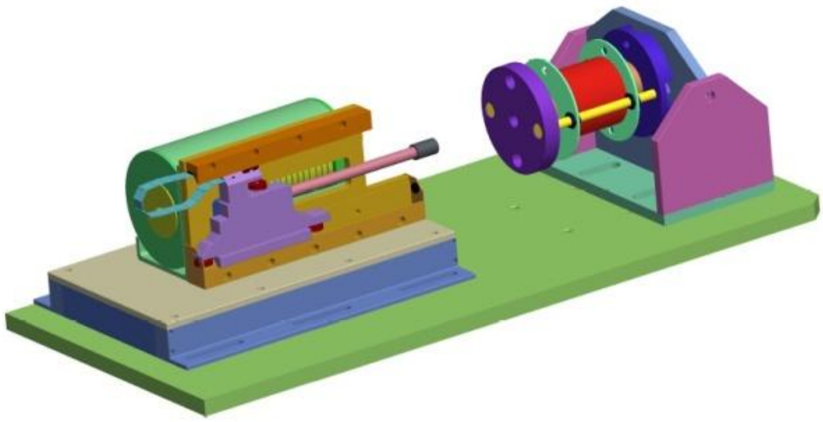

Fig. 3. Model of test stand for acquire dynamic parameters.

During experiment, mechanical, electrical and magnetic parameters changes caused by the mechanical shock of the specified amount of energy to demagnetise neodymium magnets inside of the coil were captured. The model magnet to be demagnetize was chosen on the basis of an attraction force class (e.g. N35), thermal demagnetization level and its diameter. The model of the test stand is shown in the Fig. 3 and Fig. 4 shown a photo of real test rig.

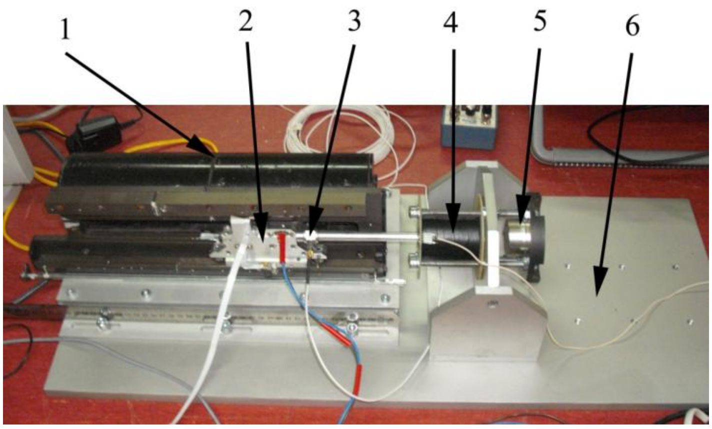


Fig. 4. The view of the harvester's test stand: 1. linear motor, 2. movable trolley of a linear motor, 3. piezoelectric force sensor, 4. inductor, 5. NdFeB magnets used for a constant magnetic field generation
around the inductor, 6. base plate with the inductor position regulation.

A beater which was accelerated to the speed of 6m/s hit the model set consisting of the neodymium magnets and caused a change in induction and an increase in current value. In the Fig. 5 example of the current flow outlined under the influence of an impact wave was presented. The maximum current value was obtained during a 20-µs-long impulse (electric power reached the value of approximately 10W).

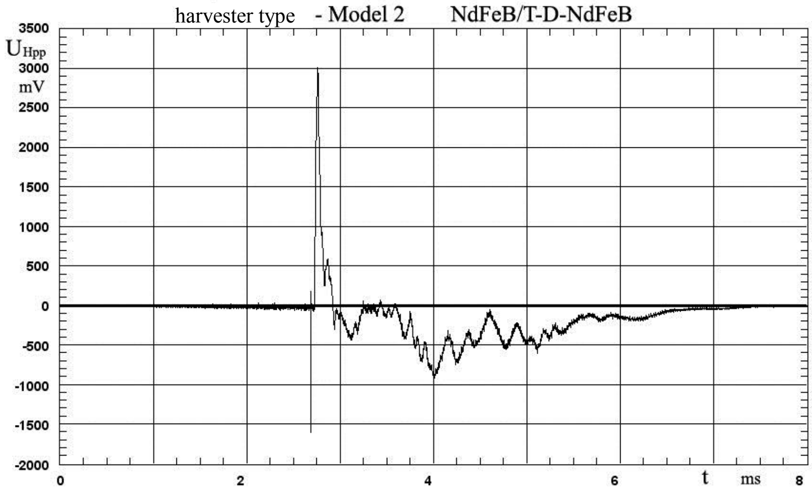


Fig. 5. The example of an electric impulse generated in the electric circuit with neodymium magnets due to the mechanical shock.

It has to be remembered that estimated efficiency value of the transformation between the mechanical shock, which occurs during the demagnetization of the neodymium magnets, and the electric current is about 0.2%. That is why, the main challenge was to improve a power transformation. In order to fulfil this challenge, it was decided to optimize system through its simplification.

This type of harvester specified as Magnet Few Turn (MFT) is one of the FMG harvesters type (Shkuratov 2002). Structure is characterized by simplicity and cost effective per watt. The coil is fixed to the neodymium magnet, directly to its cylindrical surface as shown in Fig. 6.

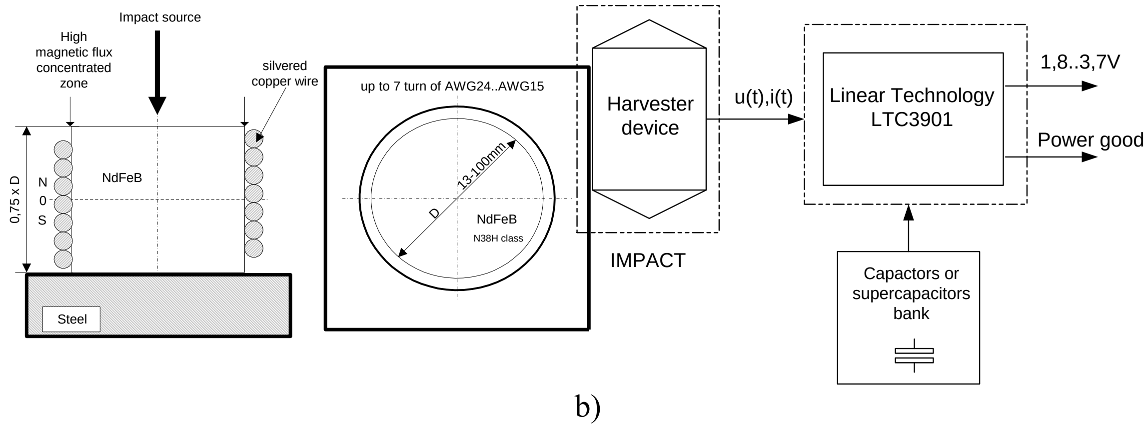


Fig. 6. Structure of MFT generator and their test circuit: a) Schema of MFT harvesting type, b) circuit with Linear Technology LTC3901 chip.

The most important intensity and value of magnetisation of the magnet. For that reason permanent magnet NdFeB from class N38H was chosen, dimensions of D = 13-100 mm. As a coil the silvered coppers wire AWG15 of up to7 turns was used.

a) b)

Fig. 7. Prototypes of MFT harvesters: a) high power harvester coupled with drop hammer, b) 6-node harvester for high impact.

Due to the high power of magnet attraction, the fastening to the flat surface of steel plate was extremely easy. As result of impact in to the magnet top surface by the nonmagnetic ram the magnetic wave was created. Due to transition of the magnetic wave a strong current impulse was generated. Prototypes of such harvesters were shown in the Fig. 7.

## RESULTS

Test was obtained to gain the waveform of this type device. The output pulse shape and $I_{coil}$ value is shown in Fig. 8. If the conditions of impact are constant the response impulses, shape and values are very repeatable.

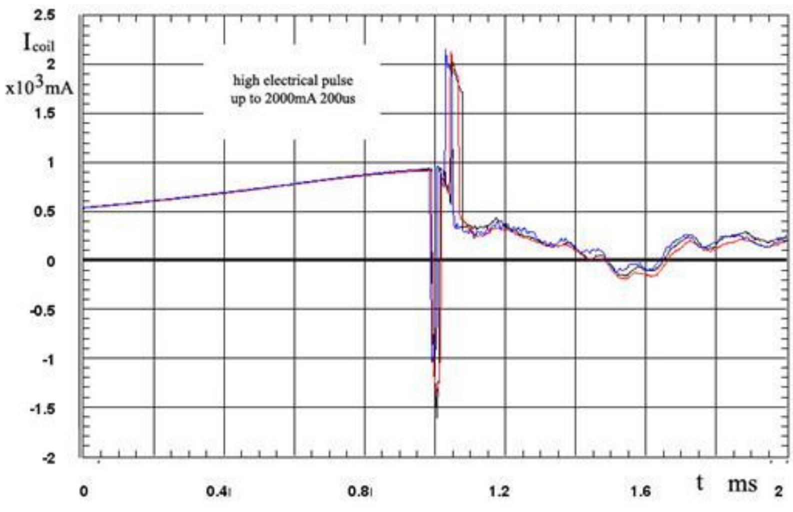


Fig. 8. The impulse of MFT harvester with 6 turn copper AWG16, magnet NdFeB Φ40mm, Rl = 125Ohm, 3 series.

Concerning other types of harvesters comparable peak currents are achievable, but due to the large density of NdFeB magnet the resonance frequencies are higher, which results in the short wave transition. To specify the usability of MFT for mechanical application further test will be necessary, however obtained values of $I_{coil}$ are promising.

## CONCLUSIONS

Described method of energy transformation allows the usage of mechanical shock to generate the electric current.

The current signal frequencies' spectrum, generated in a coil due to the wave movement, is determined by the magnetic resonance frequency. This fact allows the selection of a specific harvester depending on the working environment's frequency.

The standardization of harvesters based on their geometrical size, which should depend on their applications' requirements, is also a very important aspect. It is possible to create a series of types, from miniature ones that would be able to transform powers of a few Watts to relatively big (e.g. with neodymium magnets of Ø100mm diameter and weight of around 50kg), which could be used e.g. in mining.

In the future works, a possibility of exchanging relatively expensive neodymium magnets with the cheaper ones, which do not contain rare earth elements, should be considered.

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