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Charging a Battery with the Electric Organ Discharge of Malapterurus Electricus Catfish

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Abstract: *Energy providing to meet user's requirements is an endless cause of concern. The people living in the developed countries, (G8) represent 13.1% of the world's population. That 13.1% consumed in 2002 about 1500 Giga Joules per habitant in energy. For the remaining countries' development, the need in energy will increase up to 500% in relation with the current level of need. Hence, it is necessary to harness new pollution free sources of energy like solar renewable energies. To meet that challenge of energy by taking into account the worldwide warming pollution we have studied Malapterurus electricus catfish in order to extract the electric energy contained in the electric organ discharge (EOD) of the catfish by charging a battery of accumulators.*

Keywords *- Energy challenge, electric organ discharge, Malapterurus electricus, worldwide warming pollution*

I. Introduction

So many rivers flow through the Benin Republic, (see the map in Fig. 1-a.). Malapterurus electricus (Fig. 2-a.) that ever strongly electric catfish is a typical African knife fish, [1]. It is widespread in the sweet waters in the Republic of Benin, [2]. The country counts among the ever weakly equipped countries in the world. It is also an obvious fact that energy providing to the different end users as industries, transport, households and services in a country is the main activity on which depends the development of all others branches of the economy of that countr

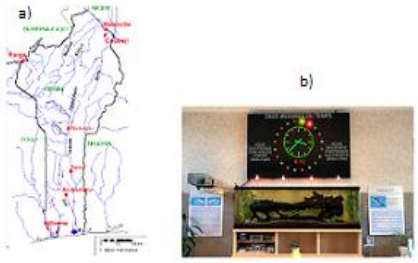

Figure 1. a - Hydrography of Benin Republic
b - Biological stopwatch in Nancy aquarium

Hence, every source of energy holding some potentiality must be scanned especially as that source is widespread in the considered area. It is just the case of the given catfish the EOD of which can reach 600 V with a frequency of 300 Hz! Malapterurus electricus is a true source of energy, [3].

Electric catfish are of course a subject of research all around the world. A team of scientists in Nancy University (France) has developed an application based on an electric catfish driving a stopwatch, (Fig. 1-b.). As we can see in Fig. 2-b., our team of research has succeeded in lighting in our laboratory a LED with the EOD of a very small size Malapterurus electricus catfish that weighs19 g. Malapterurus electricus can live in aquarium; its food habit and the characteristics of the water in its habitat are well known, [4], [5]. A battery-farming of that knife fish is quiet probable. In this way the feasibility of an energy farming centered on that catfish is quite conceivable.

The present paper reports the results of charging a 12 V battery of accumulators which really is the battery of a motorcycle Sanya 111-C type, see Fig. 9.

II. Materials and method

Figure 2. a- Malapterurus electricus catfish living in aquarium in LETIA, b- Malapterurus Electricus switching on a LED in LETIA

2.1 Determination of the electrical energy characteristics produced by the Malapterurus electricus catfish

We have determined the electrical characteristics of the EOD of Malapterurus electricus catfish. An individual of that catfish of 15 cm of length and 64.9 g of live body weight was farmed in an aquarium (Fig. 3.) in order to follow its feeding behaviour, its physical characteristics, the electrical parameters of its EOD and the parameters of the water in the aquarium, (see Table 1). The results show that Malapterurus electricus produces intermittent bursts of a frequency framed with 250 and 300 Hz, Fig. 4. Each burst lasted about half a second. The electrical organ discharge displayed on the oscilloscope showed a single curve whose dual amplitude having up to 29 V, see Table 2. Discharges were more regularly during a night (or in darkness) than during a day (or under lighting), see Fig. 5 and 6. Thus Malapterurus electricus is a typical bioelectrical voltage generator

Table 1
Average value of the parameters of the water in the aquarium

Period	Temperature, °C	PH	Conductivity, µS/cm	Oxygen ratio, mg/l
Morning, 8 o'clock	26.3	8.49	25.07	7.67
Midday, 12 o'clock	29.32	8.51	25.10	7.98
Evening, 7 o'clock	27.55	8.5	25.00	7.95
Night, 3 o'clock	26.05	8.48	25.04	7.23

Figure 3. Geometrical parameters of the catfish body; 1. Length of head = 2.41 cm; 2. Length of body = 10.7 cm; 3. Length of tail = 2.64 cm

Table 2
Recorded values of the electric organ discharge of Malapterurus electricus

Potential difference, V	Current, mA	Frequency, Hz	Signal duration, ms	Power, W
29	23.07	250-300	500	O.5307

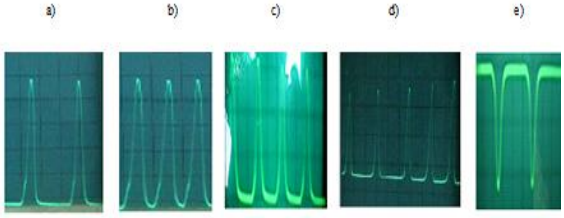

Figure 4. EOD of Malapterurus electricus with increasing number of impulses per discharge in pictures a to d then reversed in picture e

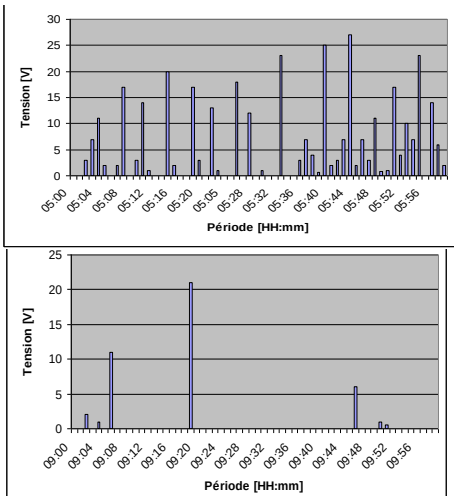

Figure 5. Recorded EOD on: a- 13/10/10 at night; b- 14/10/10 during the day time

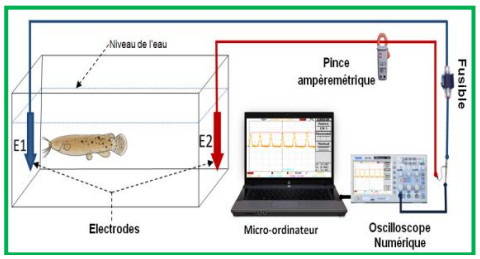

Figure 6. Connecting the catfish to an end user

2.2 Modeling the electric organ discharge of the Malapterurus electricus catfish

Figure 7a- Malapterurus electricus as an electric Dipole; b-Electromechanic model of the catfish

The electric dipole theory is applied for modeling the catfish, see Fig. 7-a. Malapterurus electricus is considered as a particular system of electric charges that are liked by a spring, see Fig. 7-b. Taking into account the main forces of that system of electric charges and applying the dynamic law, we got a non linear differential equation that we solve by the Adomian decomposition technique, [6]. Neglecting the viscous force (F_v = 0), we found the solution for that particular case as following:

$$x(t) = \sqrt[3]{\frac{\lambda}{\beta}}\left(1 - \cos 3\sqrt{\beta}\, t\right)^{\frac{1}{3}}, \qquad (1)$$

We put the relation (1) in the equation of the electric potential $V(M)$of an electric dipole and we obtain relation (2):

$$V(M) = \frac{1}{4\pi\varepsilon_0}\frac{2q(a+x)}{r^2}\cos\theta, \qquad (2)$$

The result of Simulation that model (2) in Matlab is similar to the EOD of the catfish and to a Graetz bridge rectifier output voltage in power electronics as we can see in Fig. 4 and 8-b. In fact that EOD of the electromechanical model is unidirectional like the catfish one. From now it becomes clear for us how to connect Malapterurus electricus to an end user application as lighting a LED or charging a battery.

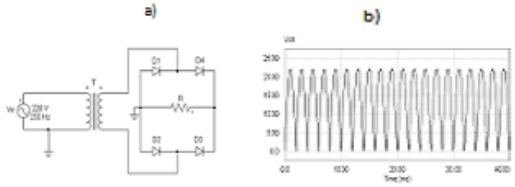

Figure 8 a- Graetz bridge rectifier; b- Output voltage of the rectifier and/or simulating result of the electromechanical model

III. Results and discussion

We know that Malapterurus electricus catfish produces strong EOD only in darkness, [2]. To reach the goal we have hidden the aquarium of the catfish with a colored paper as shown in Fig. 9- a. We stimulate the catfish from time to time by touching it carefully with a piece of wood. With the help of an interface, figure 10, the energy of the EOD of the fish is conveyed towards the battery, Fig. 9-b. Within three days the battery's voltage rises from 6 V to 9.83 V as we can notice in Table. 3. That result is given by a single catfish with a very small size! A manual exciting of the catfish cannot allow a quick operating process of charging a battery with the EOD of Malapterurus electricus of course. Hence, it is necessary to mechanize the exciting

a b

process of the catfish. For many catfish the electronic interface must include a chopper that will reduce the output voltage of the biological source of energy to the required value that can be 12 V or a multiple of it.

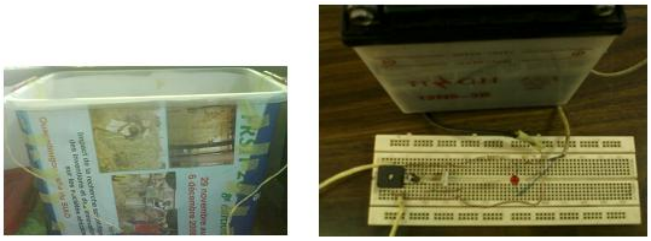

Figure 9. a- Aquarium in PVC material
b- Power transfer circuit from the catfish

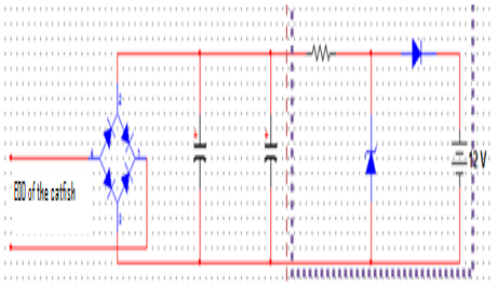

Figure 10. Interface between the catfish

Table 3
Data of battery charging

	The date											
	21/11/11			19/12/11			20/12/11			22/12/11		
Time	8	12	18	8	12	18	8	12	18	8	12	17
Voltage	6.60	7.90	8.90	8.90	9.16	9.35	9.35	9.55	9.67	9.67	9.78	9.83

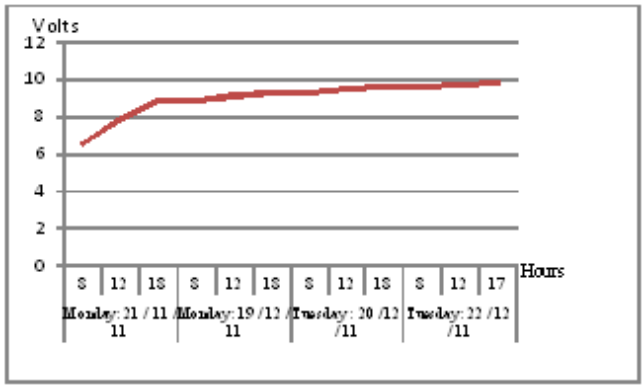

Figure 10. Characteristics of the charging of the battery

IV. Conclusion

Malapterurus electricus is really a bioelectrical voltage generator. The present study aims to use the EOD of that catfish for charging a battery in order to diversify energy sources in the Republic of Benin. An individual of *M. electricus* of 15 cm length and 64.9 g live body weight was used for the target. It was kept in an aquarium in polyvinyl chloride material. Within four days and some hours per day we have succeeded in raising the potential difference of a battery from 6 V to 9.83 V. The feasibility of the utilization of *Malapterurus electricus* catfish as a power source is now established. The recharging duration of the battery will decrease with the increasing of the number of the catfish in the aquarium. The catfish was not excited all the time during the four days recharging process. To stimulate the catfish we use to touch it carefully with a piece of wood. We'd get better from the catfish by mechanizing that operation.

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