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Human, The Electric Machine

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ABSTRACT

In modern time we are using lot of electronic devices but to run an electronic unit power generation is taking place. Major issue is it also generating problem of pollution. So, an effort has been made to harvest energy from human body for power supply. In this paper different method of energy harvesting from human body such as thermo electric power, power from heartbeat, angular knee and footsteps motion are briefly reviewed and showed that how principle of thermo electric power may be helpful to reduce abnormal level of β brain wave, caused due excessive stress and/or anxiety. An automation system can be used to control these generated power. This paper also presents a ladder logic algorithm to control for human generated power using PLC programming, with RS-232 DF1interface.

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1. INTRODUCTION

Continuous increase in the demand of electricity, it became difficult to provide electricity to every household. Increasing the no. of power plant is not a perfect solution because it will lead us to food crises and environmental issues. Renewable energy sources are one of interest area for many researchers, governments and public due to their upraising environmental impacts on greenhouse gas emission and higher power generation cost from fossil sources. For generating large amount of green power we require too much land.

As modern portable electronics devices are consuming less power, it becomes possible to use the energy harvesting from human body activity. Human body consumes a considerable amount of energy for all activities including even thinking and sleeping. For example, on an average a male having 70 Kg weight person consumes 11000 KJ in a day. Approximate electrical equivalent of above KJ is 127W. The body approximately consumes 100W when it on rest and 1630W during sprint walk [1].

It is observed that for normal daily activities, about 25% of energy is used by the skeleton and heart, 19% by the brain, 10% by the kidneys and 27% by the liver and spleen. For example a 70 Kg swimming athlete who swims 3 Km in 40 minutes consumes 770 Kcal 4.2J/cal energy with the average power of 1342W.Various active and passive methods for energy harvesting is discussed in this paper including active and passive body motion methods [2]. Human body can generate power with blood pressure, arm motion, finger motion, body heat and footsteps. Figure 1 represents possible area for power recovery from different parts of a human body [3].

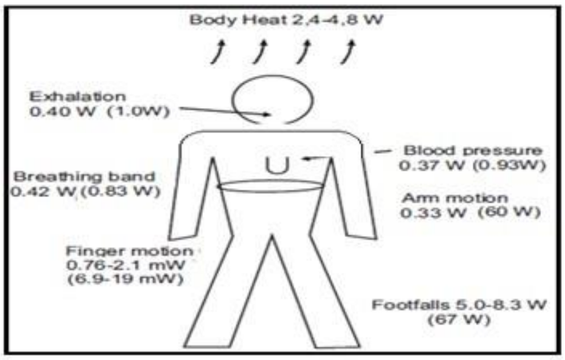

Figure 1. Human Body Energy Diagram

This micro power is useful for small equipment's like mobile charger, laptop charger etc. This paper is incorporated following features:

a. Reduction of abnormal level of β wave using thermo electric principal and analysis of wave using Lab view and Hilbert transform.
b. Development of ladder logic program to control human generated power using RS-232 DF1 interface.

2. ENERGY HARVESTING METHODS FROM HUMANS BODY

There are various methods that can be used to extract energy from human body. In this paper four of them are discussed.

2.1. Thermo Electric Power from Human Body

Thermoelectric energy harvesting from human body is affected by many factors such as ambient temperature, wind speed, clothing thermal insulation, and a person's activity. Thermoelectric devices are attached at different locations on human body.Thermoelectric devices can convert energy from heat to electricity or vice versa. It consists of many leg pairs made of semiconductor pellets, joined together using contact tabs made of high conductivity materials. According to see beck effect a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances. Basic thermoelectric circuit is shown in Figure 2. In this power harvesting system thermoelectric generators require optimization of device thermal resistance to match the human thermal load output.

Table 1 provides a perspective on the amount of power used by a human body during various activities [3]. Everyday human activity consumes power at a rate of 81-1630W, a factor of 20 in energy use.

Table 1. Human Energy Expenditure for Few Activities

Activity	Kilo Cal/h	Watts
sleeping	70	81
lying quietly	80	93
sitting	100	116
conversation	110	128
eating meal	110	128
strolling	140	163
driving car	140	163
housekeeping	150	175
carpentry	230	268
hiking, 4 mph	350	407
swimming	500	582
mountain climbing	600	698
long distance run	900	1,048
sprinting	1,400	1,630

A human being generates more than 100W of heat as a useful side effect of metabolism. However, only a part of this heat is dissipated into the ambient as a heat flow and infrared radiation, the rest of it is rejected in a form of water vapor.

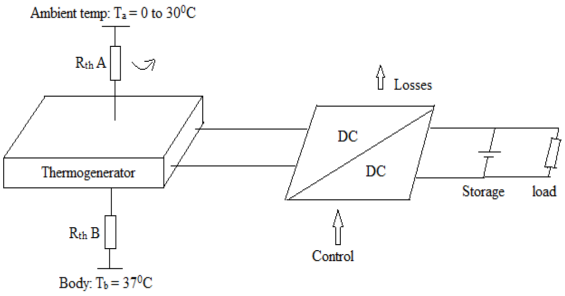

Figure 2. Thermo Electric Circuit [4]

If we implement the thermoelectric power harvesting system on brain, it will help to extract some heat of brain. Following figure was taken during electroencephalogram testing of the author. As β brain wave are involved in conscious thought, logical thinking, and tend to have a stimulating affect. Abnormal level of this β wave may lead anxiety neurosis. Generally we deal with five (α,β,γ,θ & δ) types of brain wave these waves can be treated as Bloch wave. Figure 3 is shown in EEG Testing of A Patient.

Figure 3. EEG Testing of a Patient

Neurons can exhibit a wide range of oscillations (theta to gamma-band oscillations ~4-70 Hz) and these oscillations can enter into precise synchrony over a limited period of time (millisecond scale). Recently, the role of brain oscillations in human information processing has been intensively investigated [5-9]. At present, brain oscillations at different frequencies, able to provide both temporal and spatial codes, are one of the most promising candidate mechanisms explaining the neural basis for higher-level information processing. EEG (and MEG signals arising from the brain consist of several simultaneous oscillations, which have traditionally been subdivided into frequency bands such as delta (1-3 Hz), theta (4-8 Hz), alpha (8-12 Hz), beta (about 14-30 Hz) and gamma (around 40 Hz and above).

The practical testing of the wave generated in the brain can be understood by Figure 4 & 5 which is EEG report of the patient.

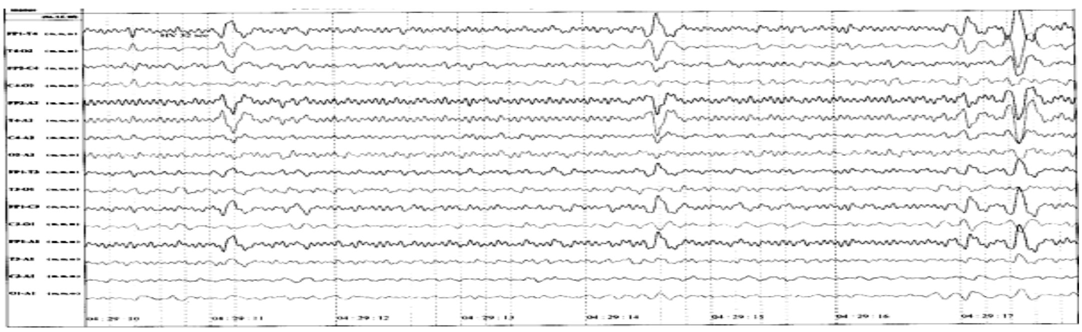

Figure 4. Normal Awake Record

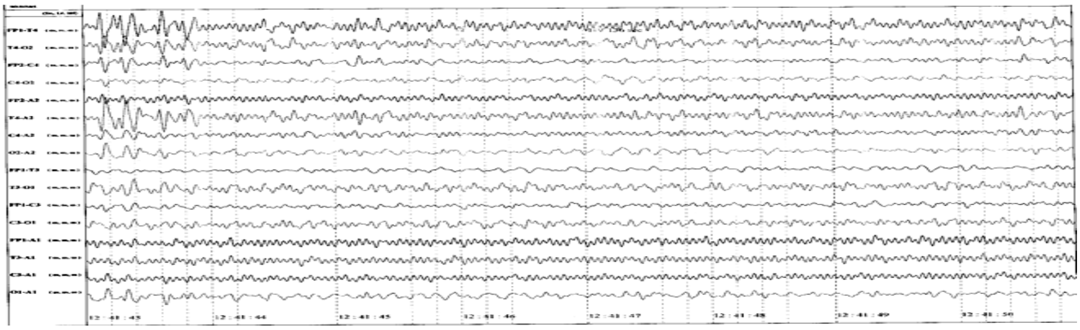

Figure 5. Abnormal Record Showing Excess Beta Activity Indicating Underlying Anxiety Neurosis

So, thermoelectric model will help to produce some voltage and also helpful for temperature reduction of a human being. A thermoelectric device placed on skin will generate power as long as the ambient air is at a lower temperature than the body. A patch of material one square centimeter in area can produce up to 30 microwatts. Place these generators side by side to multiply the amount of power being harvested.

The analytic signal, V (t), is calculated from a filtered EEG by applying the Hilbert transform. The EEG of each channel, j , denoted vj(t) , from a recording through a complete behavioral trial is transformed to a time series of complex numbers, Vj(t) , with a real part, vj(t) , and an imaginary part, uj(t). Application of Hilbert Transform as shown in Figure 6.

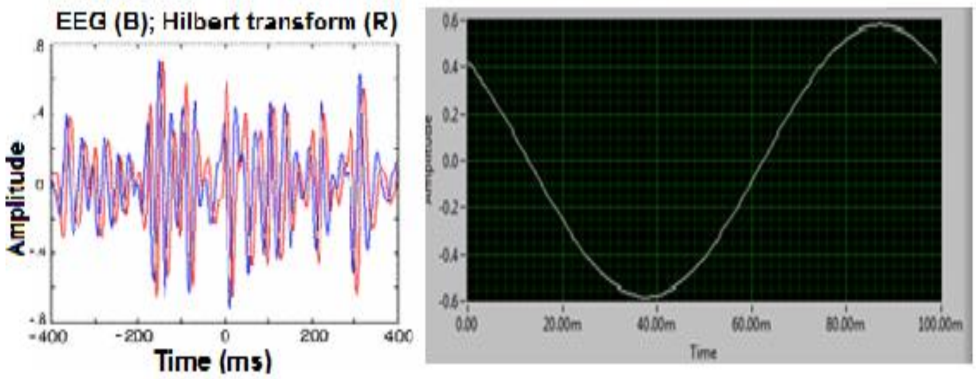

Figure 6. Application of Hilbert Transform

$$V_j(t) = v_j(t) + \tau\, u_j(t) \quad (1)$$

Where the real part is the same as the filtered EEG (Figure A, blue curve), and the imaginary part is from the Hilbert transform of Vj (t), which is uj (t) (red curve) given by equation (2) corresponding to the negative rate of change of Vj (t), the quadrature:

$$u_j(t) = \frac{1}{\pi} \mathrm{Pv} \int_{-\infty}^{\infty} V_j \ (t')/(t - t')dt' \quad (2)$$

Where PV signifies the Cauchy Principal Value, State variables from brain potentials are time series that are either recorded and digitized or derived from recordings by use of the Fourier and Hilbert transforms; they provide the primary raw materials by which models of brain dynamics are constructed and evaluated. To make a good thermoelectric it is required that

$$ZT = \frac{\alpha^2}{\rho\lambda} * T$$

Where, α = see beck coefficient –large
ρ = Resistivity –small
λ = Thermal conductivity – small

Conflicting needs are development of novel materials, material tailoring-crystal chemistry and composites-microstructure, nanostructure. In thermoelectric up-to-date best bulks are Bi2Te3/Sb2Te3, PbTe, Si-Ge and new bulk materials are Skutterudites, Heusslen alloys, Complex Chalcogenides, oxides. Some special and interesting materials which are related to power factor to highly doped semiconductors. For almost all typical thermoelectric materials, namely low gap semiconductors, if doping is increase, the electrical conductivity increment but the see beck coefficient is reduce.

$$\mathrm{Pf} = \frac{\alpha^2}{\rho}$$

Nanotechnology in thermoelectricity:-
(2D quantum wells, 1D nano wires, 0D quantum dots)

$$\mathrm{ZT} = \frac{S^2 \sigma T}{K}$$

ZT ~ 3 for desired goal
Where, S = see beck coefficient
σ= Conductivity
T = Temperature, K = Thermal conductivity
A limit to Z is rapidly obtained in conventional materials So far, best bulk material (Bi0.5Sb1.5Te3) has ZT ~ 1 at 300 K

2.2. Power from Heart Beat

Assume an average blood pressure of 100 mm of Hg (normal desired blood pressure is 120/80 above atmospheric pressure), a resting heart rate of 60 beats per minute and a heart stroke volume of 70 ml passing through the aorta per beat, then the power generated is

$$(100\text{mmHg})\left(\frac{\frac{1.013\text{x}10^5\text{kg}}{\text{msecond}^2}}{760\text{mmHg}}\right)\left(\frac{60\text{beats}}{1\text{minute}}\right)\left(\frac{1\text{min}}{60\text{second}}\right)\left(\frac{0.07\text{l}}{\text{beat}}\right) = 0.93 \quad (3)$$

This power can be easily doubled during running, but very difficult to harness it. A piezoelectric generator may be used to harness this power, which is a very reliable source to power medical implants such as a pacemaker.

2.3. Energy Harvester Driven by Angular Knee

The kinetic energy stored in the body can be converted into electricity by magneto electric, piezoelectric, magneto astrictive and electrostatic method. The development of a magneto electric based passive human energy harvester can be done from human walking and running activity [10-12]. Figure 7 shows the kinematic of the human energy harvester. The kinematics of mechanism determines how the input movement from angular knee flexing is transmitted to generate electricity. The angular velocity from knee flexing is transmitted to body 2. Body 2 transmits its angular velocity to body 3 and finally the input velocity is transmitted to the body 4 (magnet-coil system). In body 4, there is a mechanism which can produce unidirectional rotation. As a result, the permanent magnet attached to the body 4 will rotate at one direction.

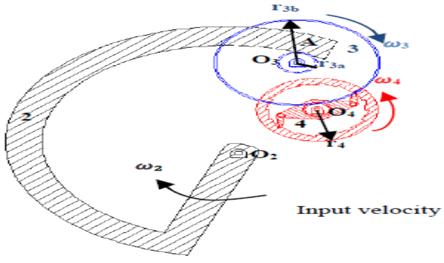

Figure 7. Kinematics of Human Energy Harvester

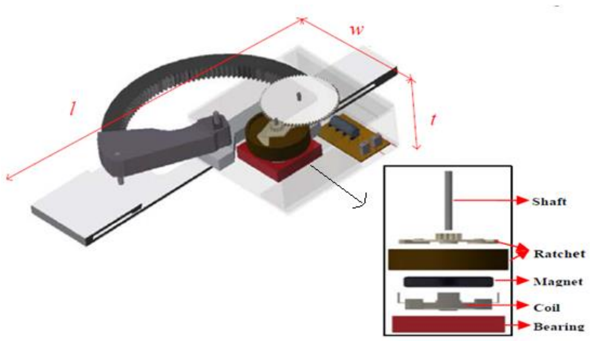

Figure 8. Human Energy Harvester Structure with Micropower Generator

The relationship between input and output Velocity is expressed as follows:

$$\frac{QzA}{r3a} = \frac{\omega 3}{\omega 2} \quad (4)$$

$$\frac{r3b}{r4} = \frac{\omega 4}{\omega 3} \quad (5)$$

Where r3a Radius of body 3a
r3b Radius of body 3b
r4 Radius of body 4
ω2 Angular velocity of body 2
ω 3 Angular velocity of body 3
ω 4 Angular velocity of body 4

Structure of human energy harvester system with micro-power generators can easily be understood by Figure 8. During walking, muscles generate torques at the ankle, knee, and hip joints. These torques acts along three axes (3-D), and their magnitude changes during the gait cycle. The most significant torques in terms of the work that is performed during the walking cycles are those acting in the axes normal to the sagittal plane. Winter and colleagues calculated the work performed at different leg joints during a single step and normalized it by the subject's weight. In addition, they divided the net work done by the muscles at the joints into several phases of motion.

2.4. Electricity Generation by Footstepsmotion

Three strategies that can be used to convert kinetic energy of human's motion into electrical power are; electrostatic, electromagnetic and piezoelectric. Electrostatic- It is based on varactors ability to produce electric charge when the area or distance of plates changes. The most significant strengths of this method are compatibility with MEMS fabrication technique besides low cost implementing. However the electrostatic method cannot be regarded as a completely self-powered strategy since it need external power supply for the initial charging. In order to improve the harvested power in electrostatic method various schemes can be applied based on principle mentioned above. For example an elastomeric generator can be used in the heel of a boot. When the heel is pressed against the ground, the pad compresses the mounted elastomeric membrane for producing a voltage. When a voltage is applied across the electrodes, then it produces energy.

Electromagnetic- When a magnetic material moves in the electromagnetic field, a voltage will be induced on a coil surrounded it. Basically an electromagnetic system must include a coil and a permanent magnet attached to an elastic element and typically the mechanical movement in such system caused by structural vibration. The magnetic field in the coil will be easily induced if the magnet is large. However, the size and layout of the magnet is limited by the spring and the structure of the device itself. Considering the natural walk movement, tried to implement electromagnetic generator in shoes. The application of a permanent magnet in a shoe can be viable since walking provides a shift in the magnet coil causing a magnetic field that generates energy. This prototype is implemented in a shoe only with a spring, a pendulum and a generator system that produces a peak power near 1W i.e. enough energy to power a radio during a walk [2].

Piezoelectric- Specific ability of another class of smart materials such as PZT, PVDF or MFC to produce electricity from an applied mechanical force is particularly useful for harvesting energy from external passive motion like talking [13-19]. The fundamental equation in these materials is stated by

$$\begin{pmatrix} T \\ D \end{pmatrix} = \begin{bmatrix} c & -e^t \\ e & \varepsilon \end{bmatrix} \begin{pmatrix} S \\ E \end{pmatrix} \quad (6)$$

In this matrix equation T, D, S and E are stress, electrical displacement, strain and electrical field, respectively. In the matrix of coefficients c, e and are Young's Modulus (elastic stiffness), piezoelectric stress constant and permittivity (ability of electrical charge production), respectively. The mechanical energy can be any kind of compression, tension and bending forces. These transducers have been used for many applications from industrial measurement systems to research measurement as well as in generating mechanical waves in ultrasonic transducers and medical applications. A distributed pressure load applied on a piezoelectric film causes an electrical charge displacement as depicted in Figure 9.

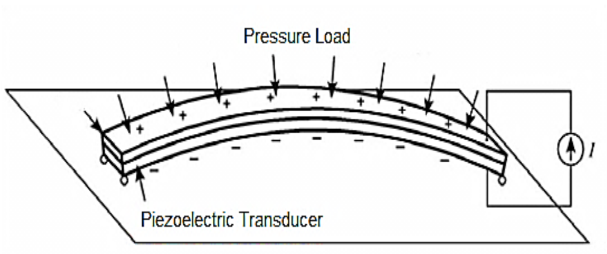

Figure 9. Piezoelectric arrangement for Harnessing Power

Various configurations of piezoelectric material can be used for energy harvesting purpose. For instance piezoelectric transducers have been recently used to design energy harvesting shoes. They can scavenge some power from walking energy and the dynamics of the force on the heel and toes [20-23].

3. AUTOMATIC CONTROL OF GENERATED ENERGY

Human energy harvester technologies are required automation due to relaxation tendency of human body after certain time. Continuous harvesting of power from human body may lead health problem. In lieu of above duty of power generation devices are controlled by Programmable Logic Controller. An algorithm for automatic control of electric power generation from human body is proposed using RS-232 DF1interface. Controlling the various devices with the programmable logic controller can be used only in the case of group power generation system. For a single person small controller circuit is required [24-26].

3.1. Ladder Logic Programming Algorithm for Controlling of Human Body Energy System

Rung 1	[XIO] is connected to <MCR> for the permission operation of whole command. If<MCR> is not on then not any single line will be executed.
Rung 2	Having two numbers of [XIO] switch and an output and binary supply is provided the rung is used for the holding operation. In limited no. of output we need to use holding [B3:0].
Rung 3	Having connected with<TND> used for the temporary end of program if the user wants to stop the whole generation.
Rung 4	[XIO] is connected to <JMP> for skip the section of programming not to exsiccate up to the defined level. The system may be generating or load on produced energy. If user wants to continue the process without any break then the <JMP> and <LBL> must be use before the rung not supposed to execute.
Rung 5	If a person wants to close the system after some time for proper functioning of body so the TOF 'T4:0' timer can be use according to the time the value of (.acc) and (preset) can adjusted in program.
Rung 6	TT or DN bits can be given according to user so output section can be controlled through it.
Rung 7	A <LBL> i.e. the label is used for the defining the jumper section of program placed on rung 3.
Rung 8	Examine if open switch is used to run CTU i.e. Up counter.
Rung 9	DN bit of CTU is connected with the o/p i.e. O: 0.0/3. For distribution system and protection use of CTU 'C5:0' and CTD counter can be used with using DN bit.
Rung 10	Having connected with the compute operation command for two sources.
Rung 11	Connected with logical/move command for the combination operation of two sources.
Rung 12	Closing point of <MCR> or fixing portion of program control.
Rung 13	End of the ladder logic program.

4. CONCLUSION

Existing methods of energy harvesting from humans body has been discussed. Thermo electric technology can also be used for reducing temperature of the human body. Continuous power generation from body may lead health problem. Thus, human energy harvesting technology requires automation control and this automatic control can achieved using AB PLC, RS-232 DF1 interface or using small controller circuits. Programming logic controller can only useful in the case of group power harvesting system. For individuals small controller circuit can be used. It is analyzed that the harnessing power from footsteps and angular knee is more suitable as compared to other method.

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