ENERGY HARVESTING AND STORAGE SYSTEM FOR WEARABLE DEVICES

ATAL FDP @SRIT,COIMBATORE

DR.R.JAYAPAL

AUTOMATION CONSULTANT

www.elecspot.com

drrj1950@gmail.com

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Common examples of wearable devices (Medical-Both implant and non implant)

Pace maker

Smart sleep wearable

Biopatch (Monitoring ECG,Pulse)

Smart glass (AR/VR)

Smart hearing aid

Wireless patient monitor

Wearable Ring (SOS Alert)

Common examples of wearable devices (Non Medical)

Smart jewelry, such as rings, wristbands, watches and pins. Smaller devices typically work in coordination with a smartphone app for display and interaction.

Body-mounted sensors that monitor and transmit biological data for healthcare purposes.

Fitness trackers, often in the form of wristbands or straps, that monitor things like physical activity and vital signs. Trackers may connect wirelessly to an app for data storage, processing and reporting.

Smart clothing with built-in technology that can perform a variety of tasks including fitness or health monitoring, interacting with phones and other devices and changing fabric characteristics to suit the user's preference, activity or environment.

Development of micro generators to eliminate the necessity of batteries

-in autonomous and stand-alone devices

-in devices that are difficult to access.

Energy harvesters are being developed for the same purpose

An energy harvester (also called an energy scavenger) is a small power generator that does not require any fuel.

Instead, it uses energy available in the ambient, such as electromagnetic energy, vibrations, wind, water flow, and thermal energy.

Energy harvesting technologies:

1. Thermal:

   Thermo electric generator (TEG)

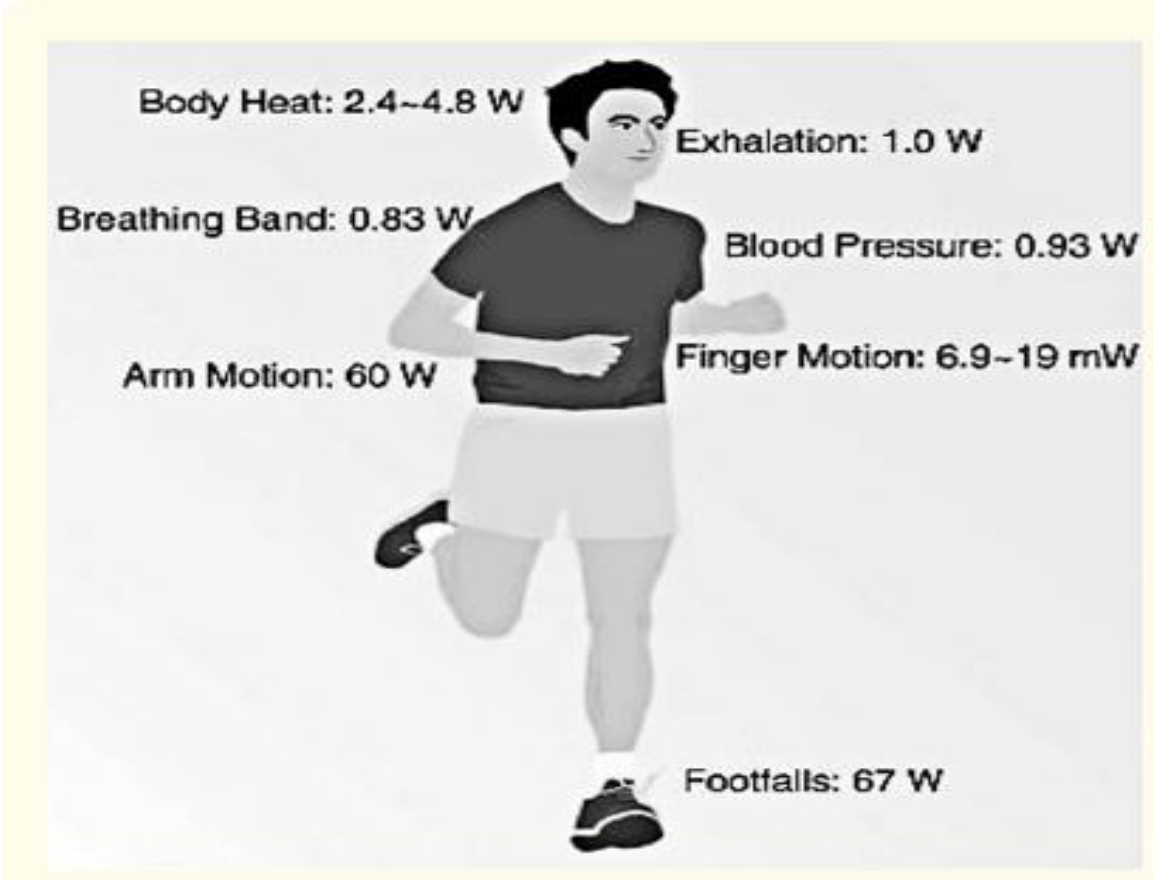
2. Mechanical :

   1. Piezo electric generator (PEG)

   2. Triboelectric generator (TEG)

3. Electromagnetic:

   Energy from light/sound/EM waves

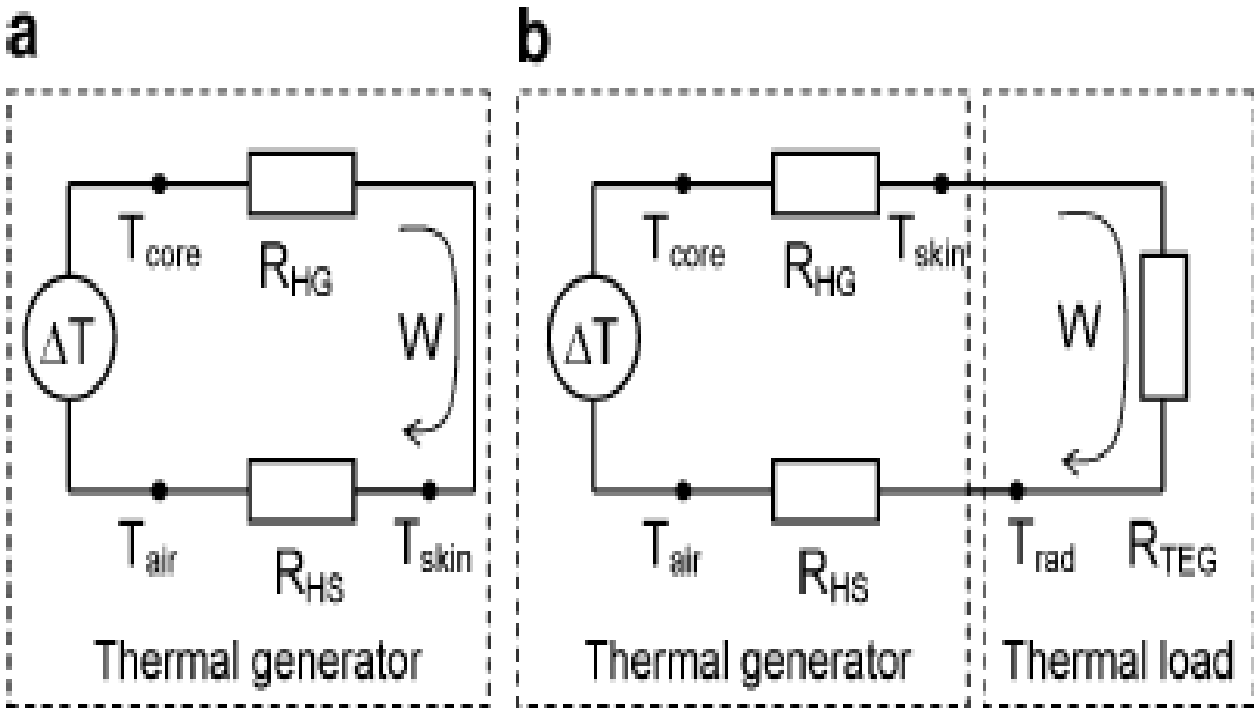


Bio energy released by body

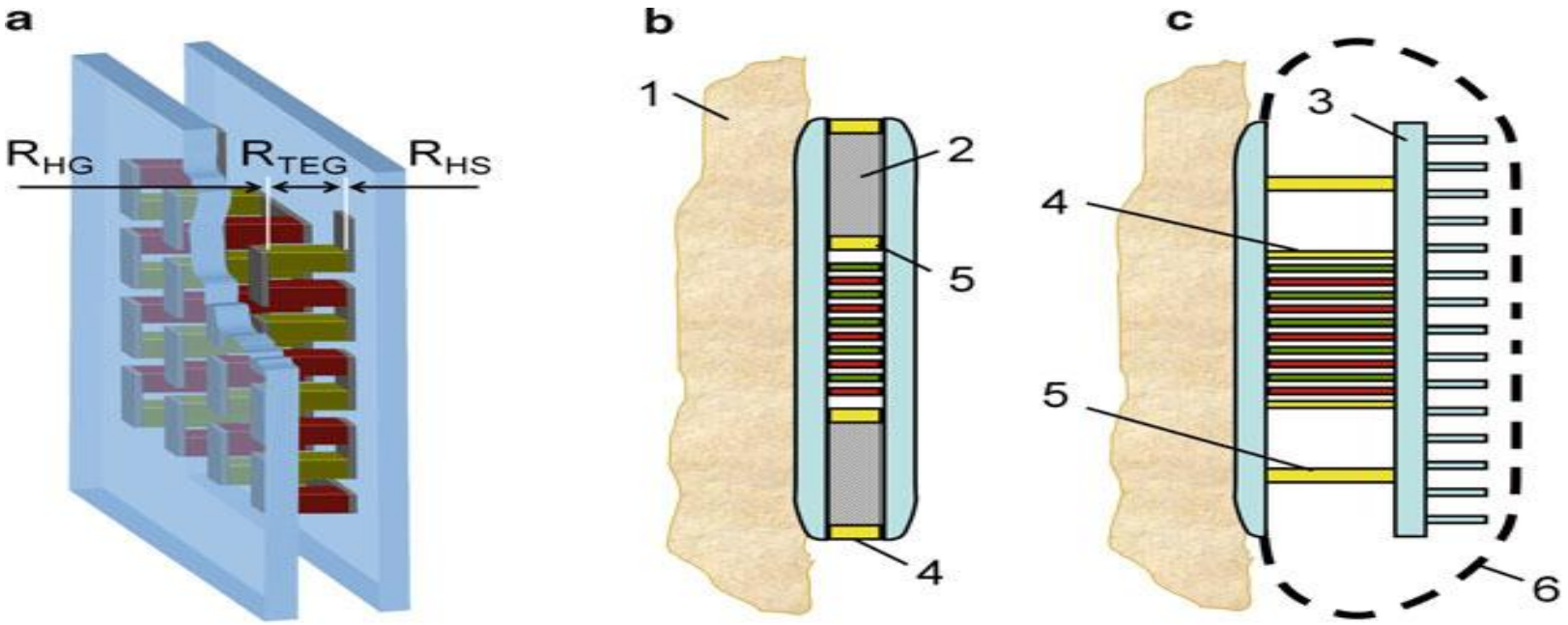
Principles of Energy Harvesting by Using Human Body Heat

The heat flow from body to ambient can be converted into electricity by using a thermoelectric generator (TEG), the heart of which is a thermopile.

A human being generates more than 100 W of heat on average. Even about 1–2% of this heat can be used, an electrical power of the order of milliwatts can be obtained using a person as a heat generator.



Thermal equivalent circuit
Natural thermal generator b) Generator with thermal load
RHG-Thermal resistance of body. RHS-Thermal resistance of ambient Air. W-heat flow



Energy harvesting using human body heat flow

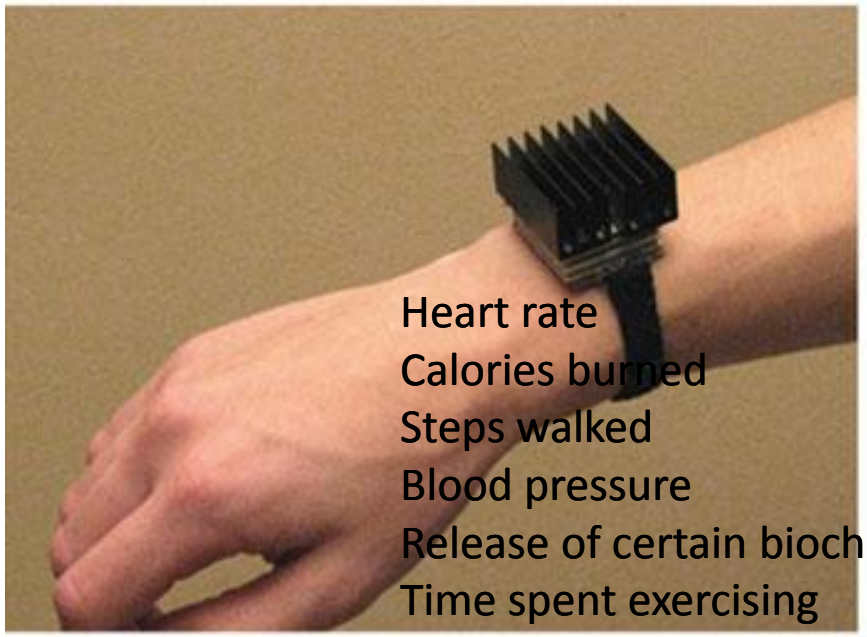
a.Thermopile between hot and cold electrodes

b.Cross section of TEG

c.Air filled TEG with radiator

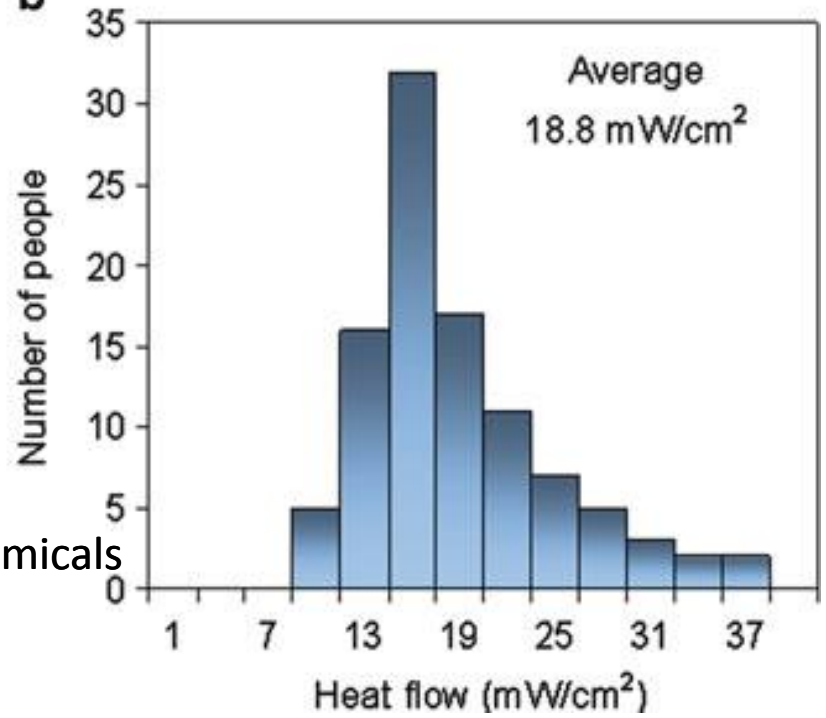
1. Human skin 2. Thermal conductivity material 3.Radiator 4.Encapsulation wall
5. Regid support 6. Thermal isolator

a



Heart rate
Calories burned
Steps walked
Blood pressure
Release of certain biochemicals
Time spent exercising
Seizures
physical strain[48]

b



a. TEG on the wrist (Watch/Fitness band)

b. Heat flow through TEG per sq.cm of skin measured on the wrist of 100 people sitting in a room

Smart watch functions:

Heart rate
Calories burned
Steps walked
Blood pressure
Release of certain biochemicals
Time spent exercising
Seizures
Physical strain
No activity warning

Future Smart watch functions:

Forecasting changes in mood, stress, and health
Measuring blood alcohol content
Measuring athletic performance
Monitoring how sick the user is
Long-term monitoring of patients with heart and circulatory problems
Health Risk Assessment applications, including measures of frailty and risks of age-dependent diseases
Automatic documentation of care activities.
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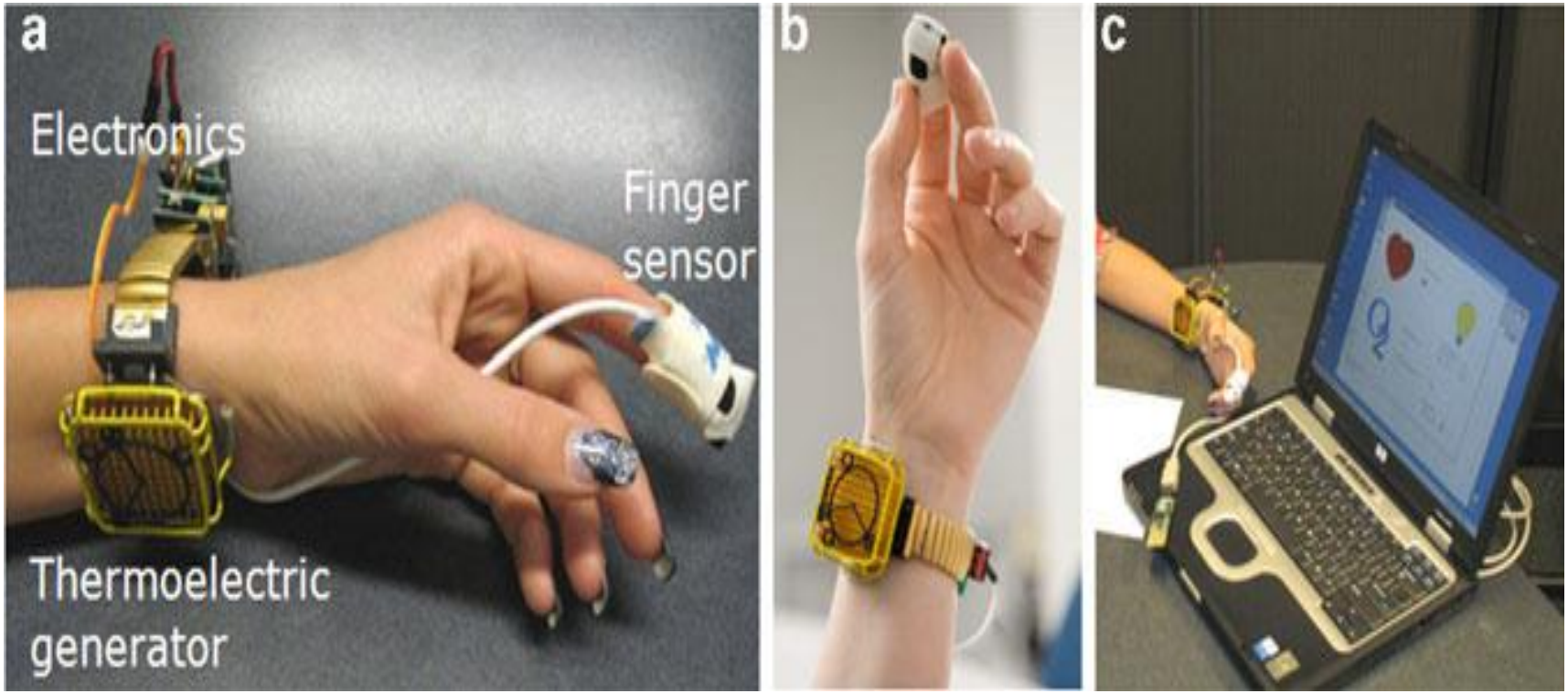


Body powered pulse oxymeter

Self powered EEG

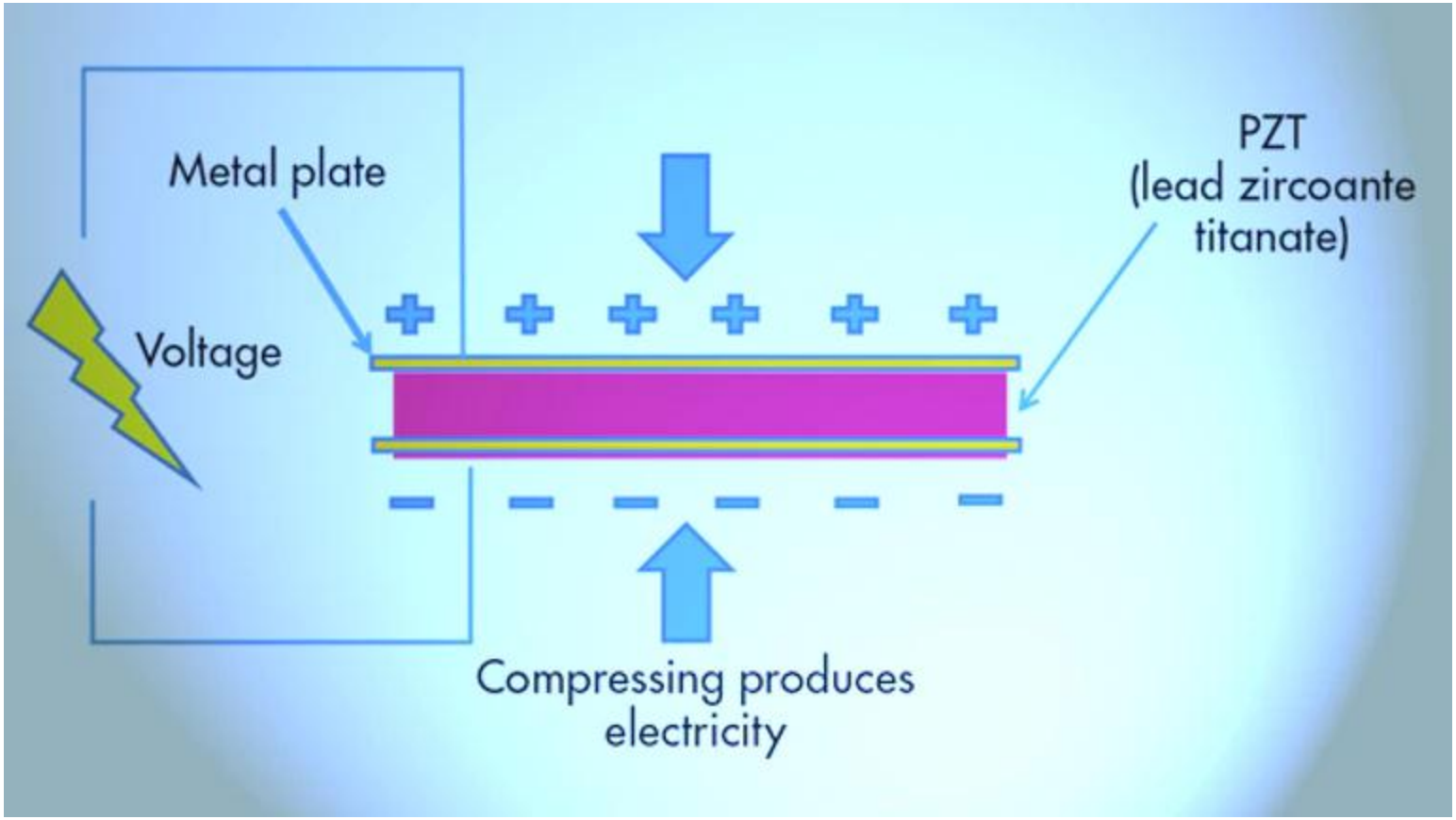
a,b are TEG in assembly stage. C is complete product

1.Thermopile 2.Hotplate 3.Radiator 4.Electronics module

Mechanical source:

1. Piezoelectric generator (PEG)

2. Tribo electric generator (TEG)



Piezoelectric effect

Piezo electric generator:

-Fabric woven with piezo electric fibre

-It is integrated into shoe soles

-Kinetic energy of human body is converted into electrical energy to power the wearable device in shoes

-Typical PE materials-crystals, ceramics, polimers,proteins

-Widely used-PolyvinyliDene flouride (PVDF)

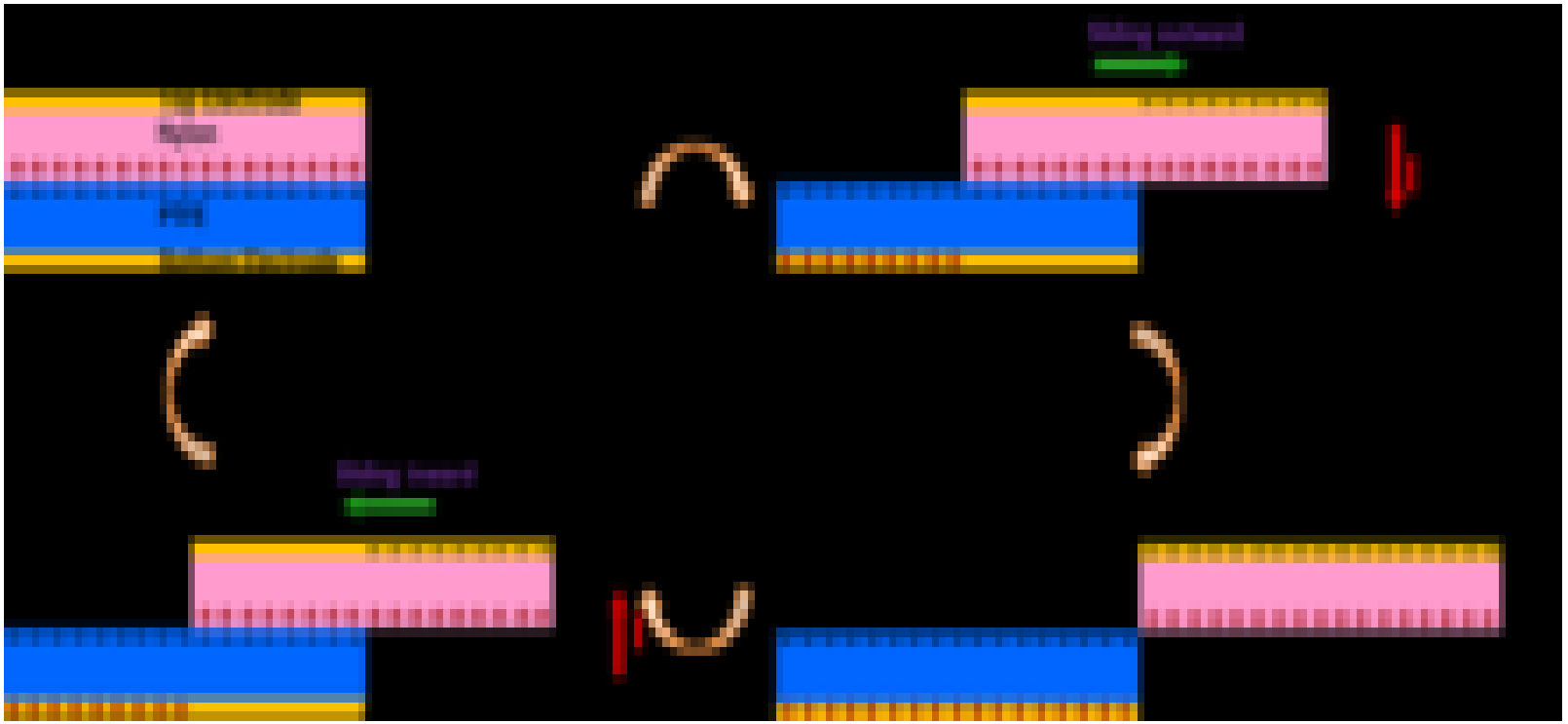
Lead zirconate titanate Piezo Transducer (PZT)

Wearable piezo electric energy harvesters

Source	Material	Power (mW)
COG	PVDF	9.1 mW @ 1 Hz [1]
COG	PZT	0.15 mW @ 1 Hz [2]
Foot strike	PZT	8.4 mW @ 1.1 Hz
Foot strike	PZT	90.3 mW @ 1 Step
Foot strike	PVDF	0.013 mW @ 1 Step
Foot strike	PVDF	1 mW @ 1 Hz
Foot strike	PVDF	0.5 mW @ 0.5 Hz
Foot strike	PZT	0.35 mW @ 8 km/h
Knee	PZT	3.5 mW @ 0.9 Hz
Knee	PZT	5.8 mW @ 0.9 Hz

COG-Centre of gravity motion of upper body
PVDF-Poly vinylinene Flouride
PZT- Lead zirconate Titanate

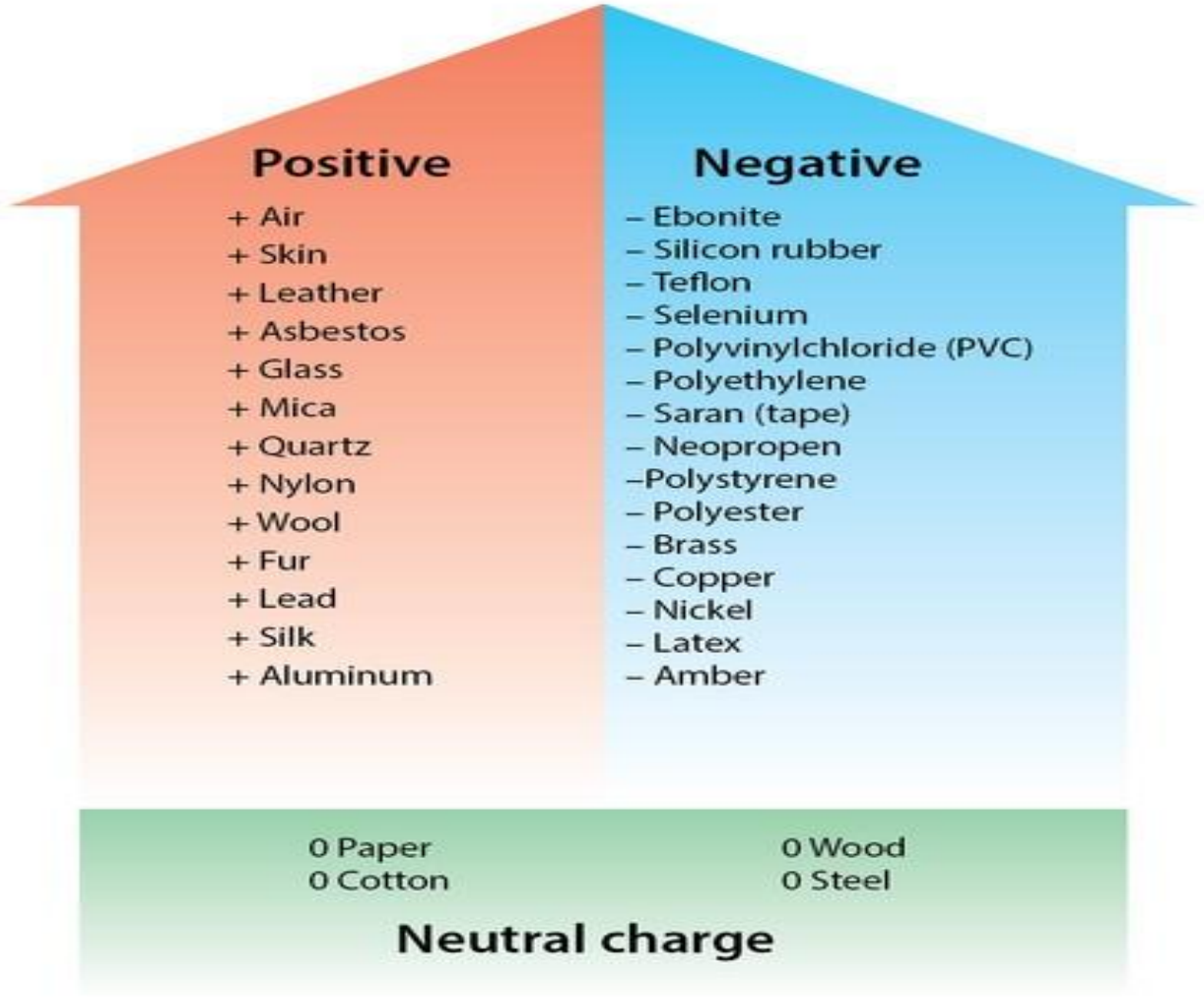
Triboelectric effect



Some material becomes electrically charged when comes into frictional contact with another material. Displacement between them generates electricity which is Triboelectricity (Static electricity

Top Electrode-Nylon: Bottom Electrode-PTFE

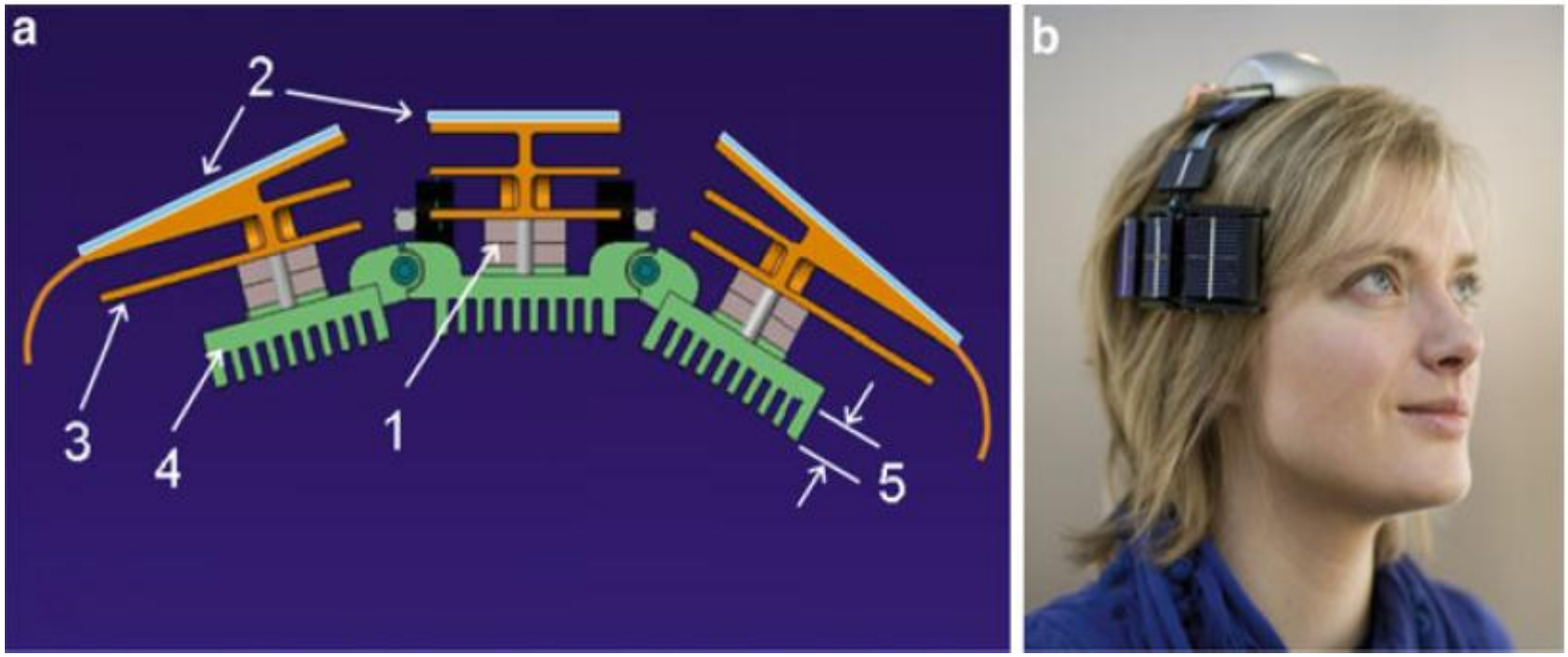
Tribo electric materials



Wearable tribo electric energy harvesters

Source	Power
COG	$V_{OC} = 428$ V, $I_{SC} = 1395$ µA
	1.17 W (peak)
Foot strike	1.4 mW (peak)
Foot strike	$V_{OC} = 220$ V, $I_{SC} = 600$ µA
Foot strike	2.1 mW @ 1.8 Hz
Foot strike	$V_{OC} = 810$ V, $I_{SC} = 17.7$ µA
Foot strike	4.9 mW (peak)
Foot strike	0.25 mW @ 0.9 Hz (rms)

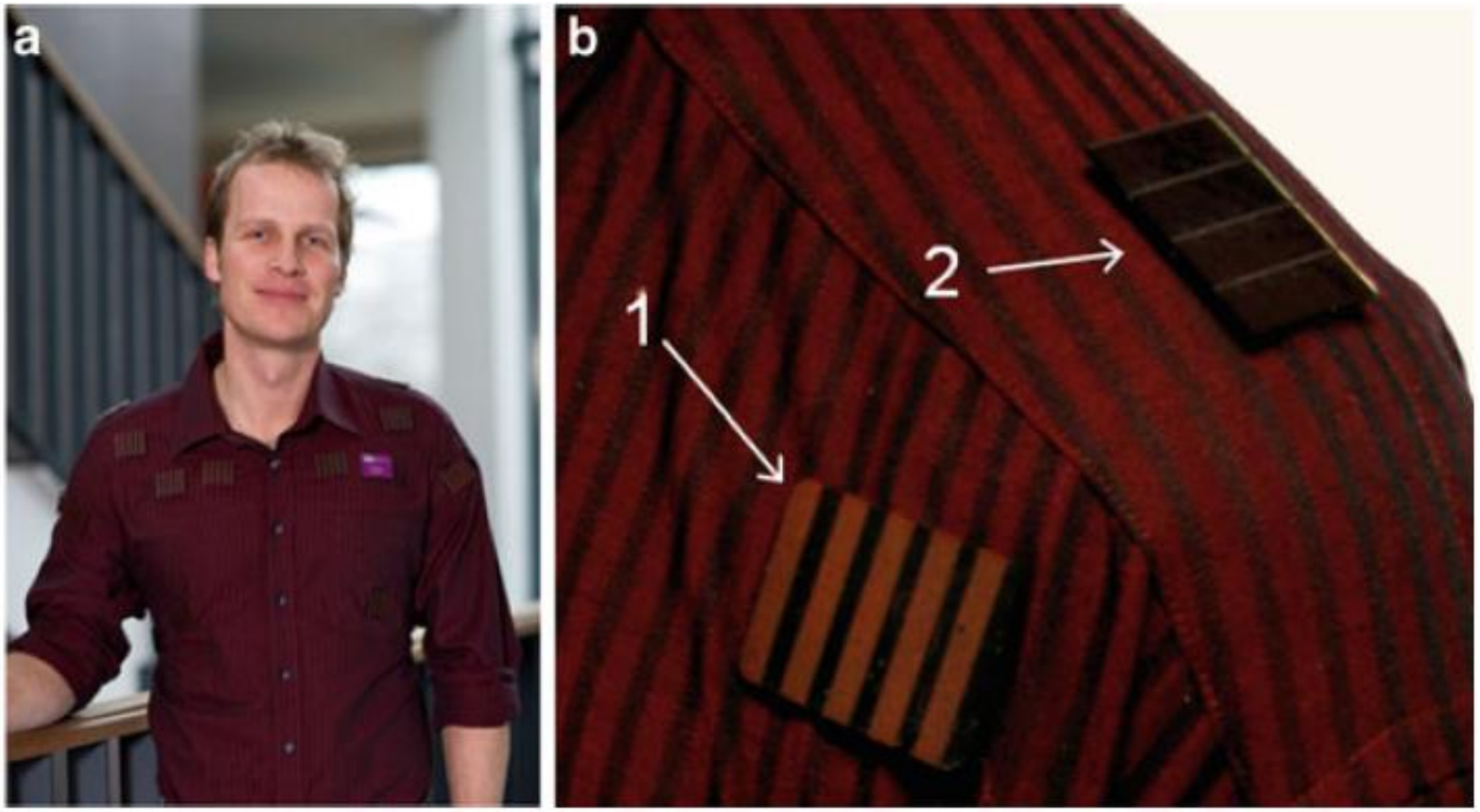
Combined Solar cell and TEG power source



a) Cross section of Hybrid power source for EEG
b) Two channel EEG

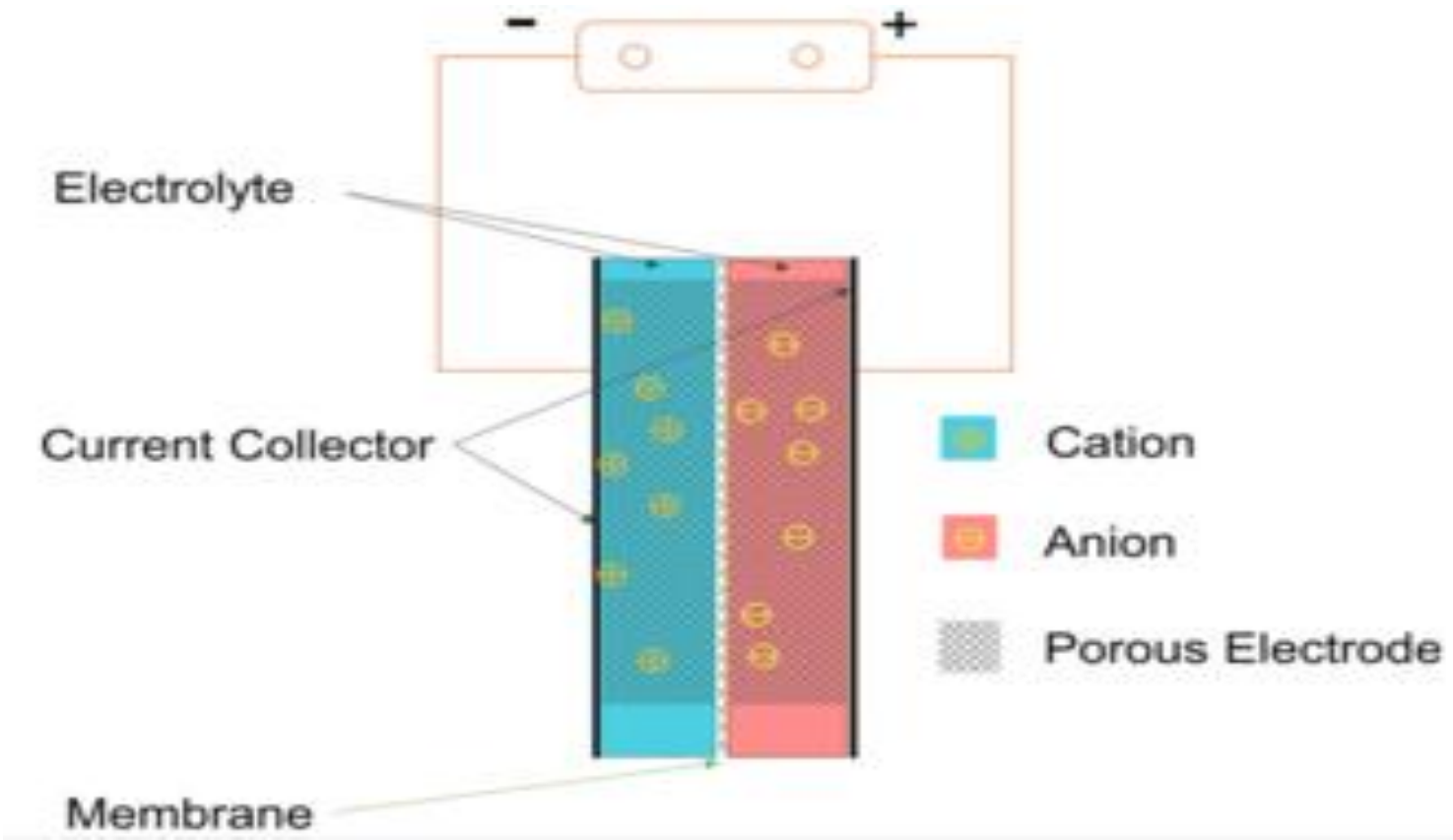
1. Thermopile 2. PV cells 3. Radiator 4.Hot plate 5.Thermal shunts

Powering of ECG system in shirt



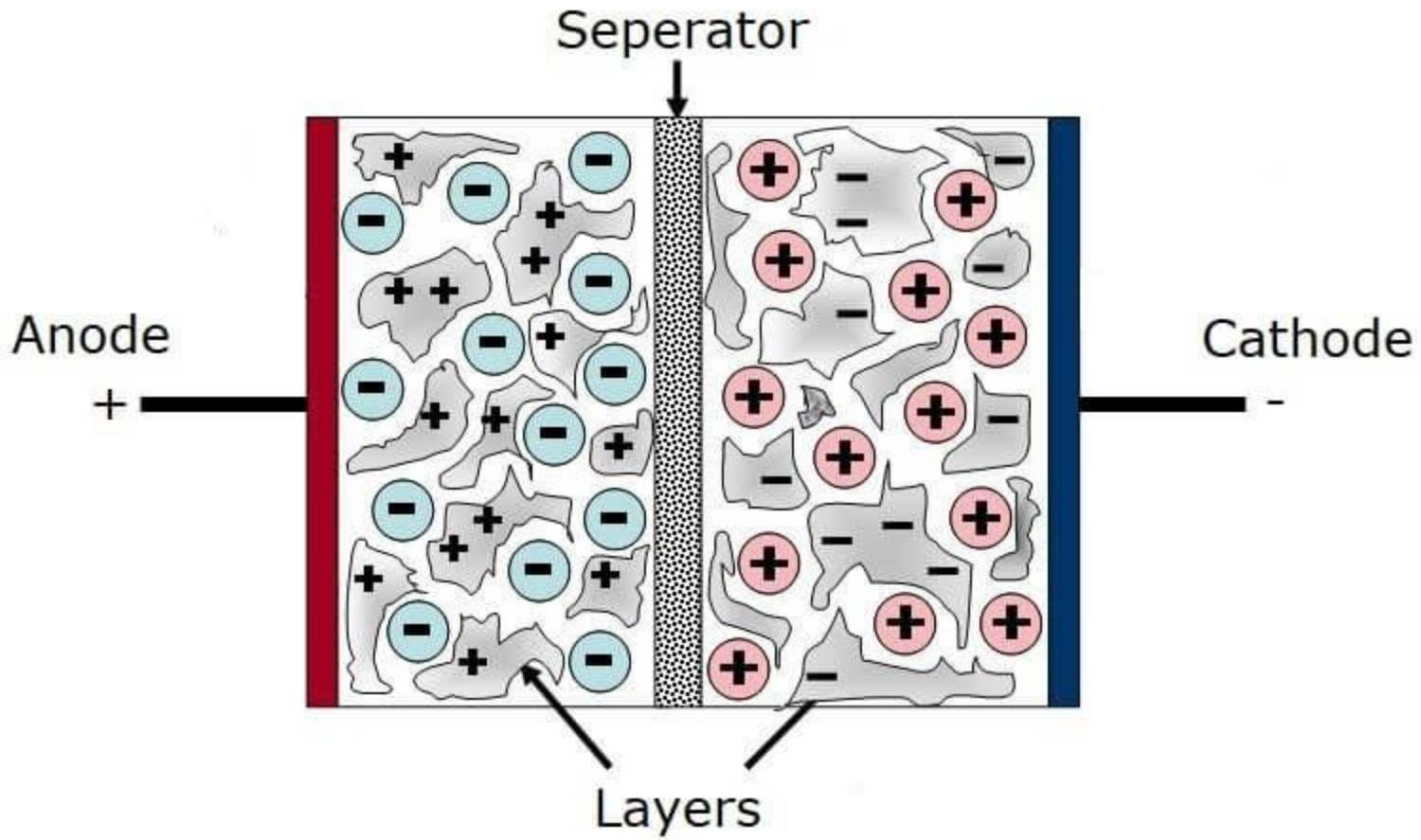
a) ECG system integrated in a shirt b) Thermo electric module (1) and PV cells(2)

Super capacitor



Super capacitor or ultra capacitor is high capacitor with lower voltage limits

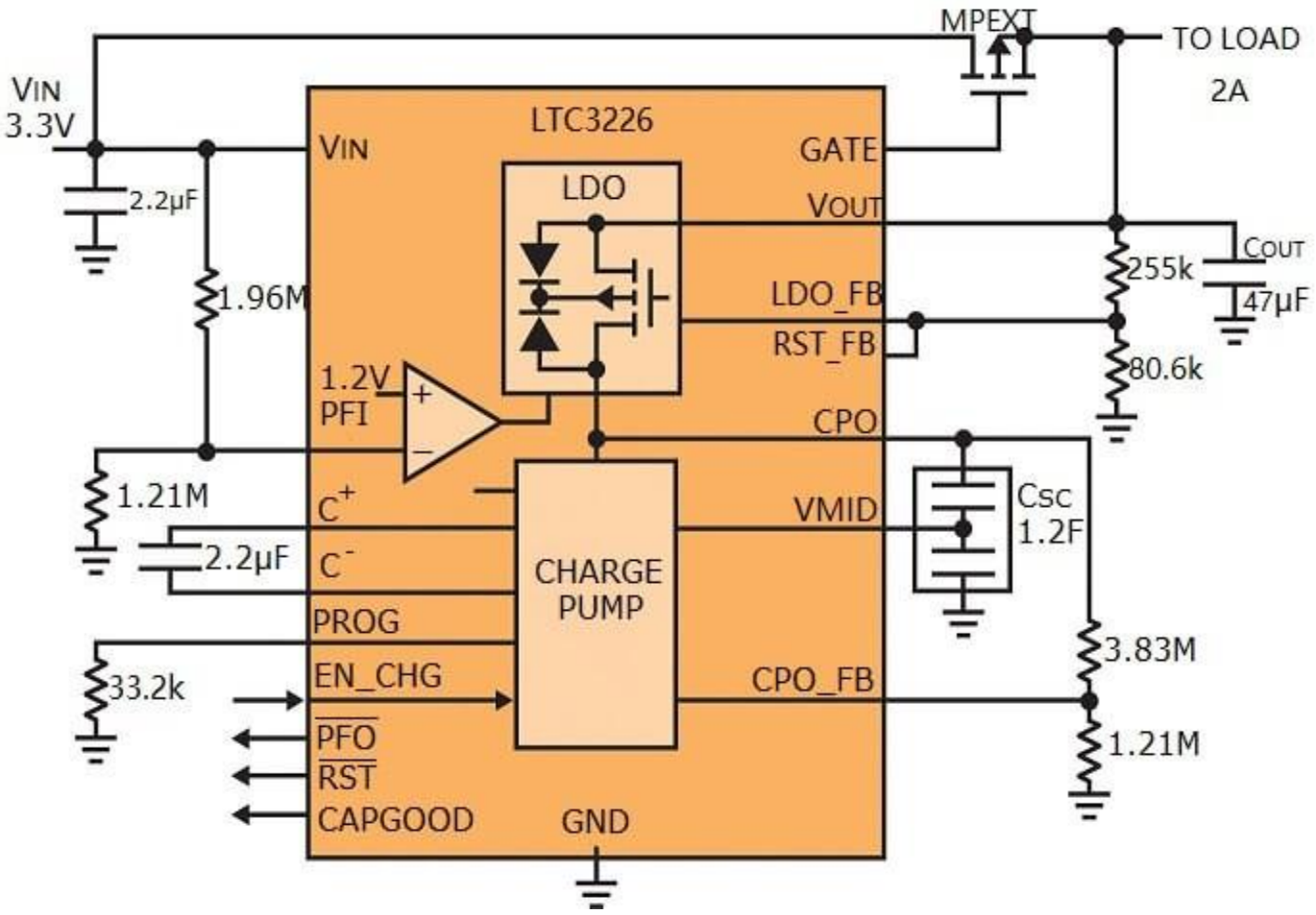
Super capacitor



Two Types : 1. Electrical double layer capacitor

2. Electro chemical double layer capacitor /Pseudo capacitor

Typical power back up withSuper capacitor



Super capacitor

Characteristics

-Very good life-1 million charge cycle

-Operating temperature- -50 to +70 deg C

-Unlike battery, no harmful chemicals

-Unlike battery, no bursting hazard

-Unlike battery, no maintenance

-Low voltage rating around 2.5 Volts only

-1 Farad super capacitor commercially available

How to reduce power consumption in wearable electronics?

- MOS technology
- Use lower operating voltage
- Use dual power supply to improve speed on critical path and lower consumption in non critical path
- Power gating-use of sleep transistors to disable entire/selected blocks
- Reduce operating voltage during logic state change
- Provide charge to capacitive loads through resistive paths
- Use of clock gating technique
- In wireless communications, use power aware protocols

New power sources under research

-Nano vascular turbine implanted in human arteries to run pacemaker consuming 10 microwatts (University of Bern, Switzerland)

-Invention of a fiber <1 mm thick producing electricity when immersed in blood (Fudan university,China)

-Development of Powerfelt producing power from body heat . Application is charging cellphone using cloth cover made of Powerfelt. (Wakeforest university)

- Piezoelectric tiles in walk ways to produce power

- Producing power from human waste (urine,excreta) using microbial fuel cell (Bill & Melinda foundation grants)

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You may read a book “ What was wrong?” available in Amazon,Flipkart. It is a book on electrical malfunctions.

My number; 9994687310. drrj1950@gmail.com

THANK YOU