HUMAN BODY THERMAL ENERGY HARVESTING FOR WEARABLE DEVICES

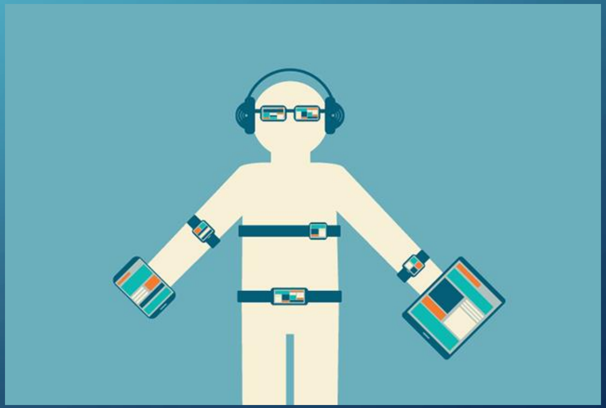
DR. HESSA AL-JUNAID

COLLEGE OF INFORMATION TECHNOLOGY

UNIVERSITY OF BAHRAIN

INTRODUCTION

- Advances in the electronics industry is in continuous reduction of devices sizes as well as the power used to operate them.
- This power requirements reduction has created an interest in new methods of powering these devices as alternative to disposable battery technology.
- The rise of using battery operated electronic devices connected to human body. Medical monitoring and aid (hearing aid, temperature measurement), as well as consumer electronics (electronic watch, headphones)



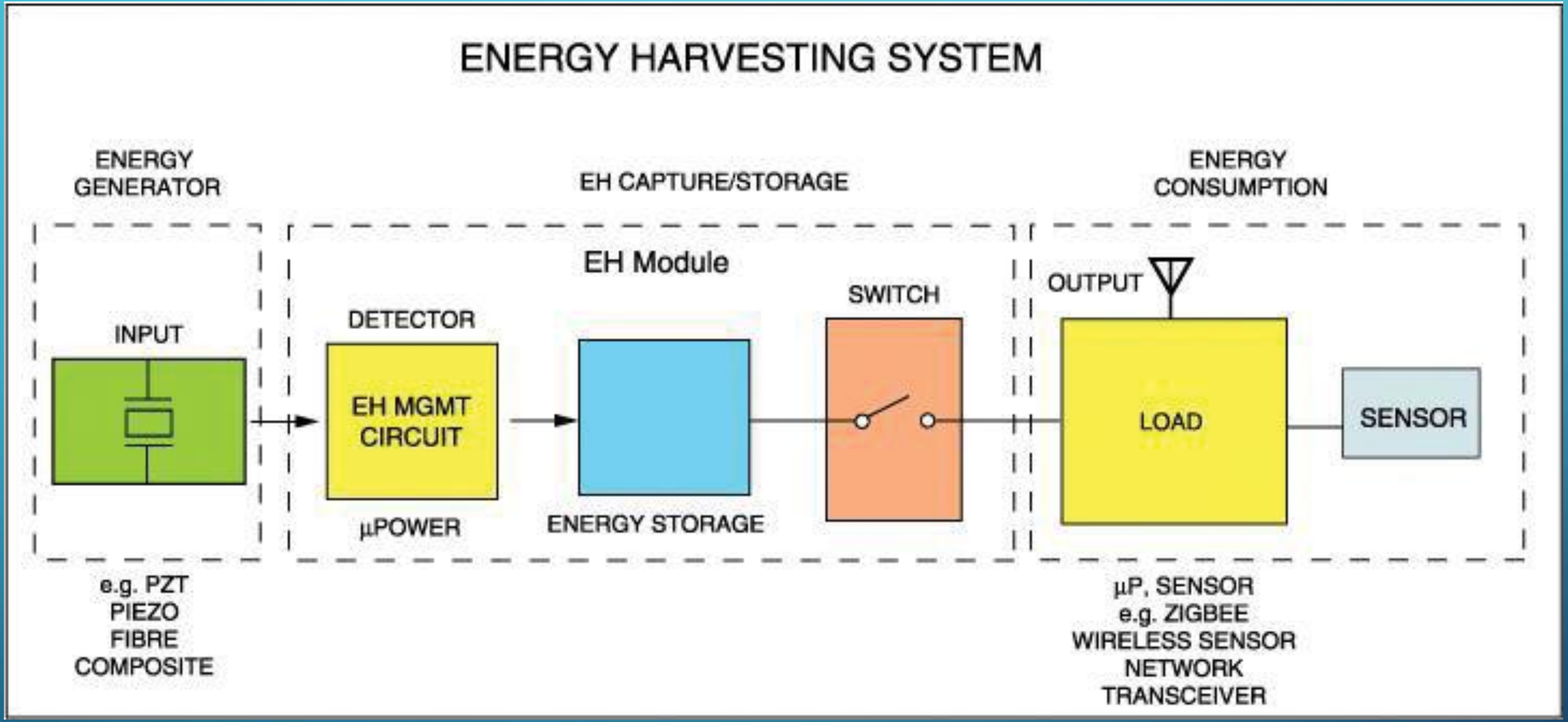
INTRODUCTION:

- Energy harvesting is a growing field of interest for researchers and the industry.
- Energy harvesting is small power generating without fossil fuel. Generators uses energy available in the ambient, such as an electromagnetic energy, vibrations, a wind, a water flow, and a thermal energy and converting it to electrical energy.
- The main application is to use them to power sensors nodes.
- The advantage is to get rid of wiring and cost ineffective recharging or replacing batteries, volume and weight caused by batteries.

OBJECTIVE:

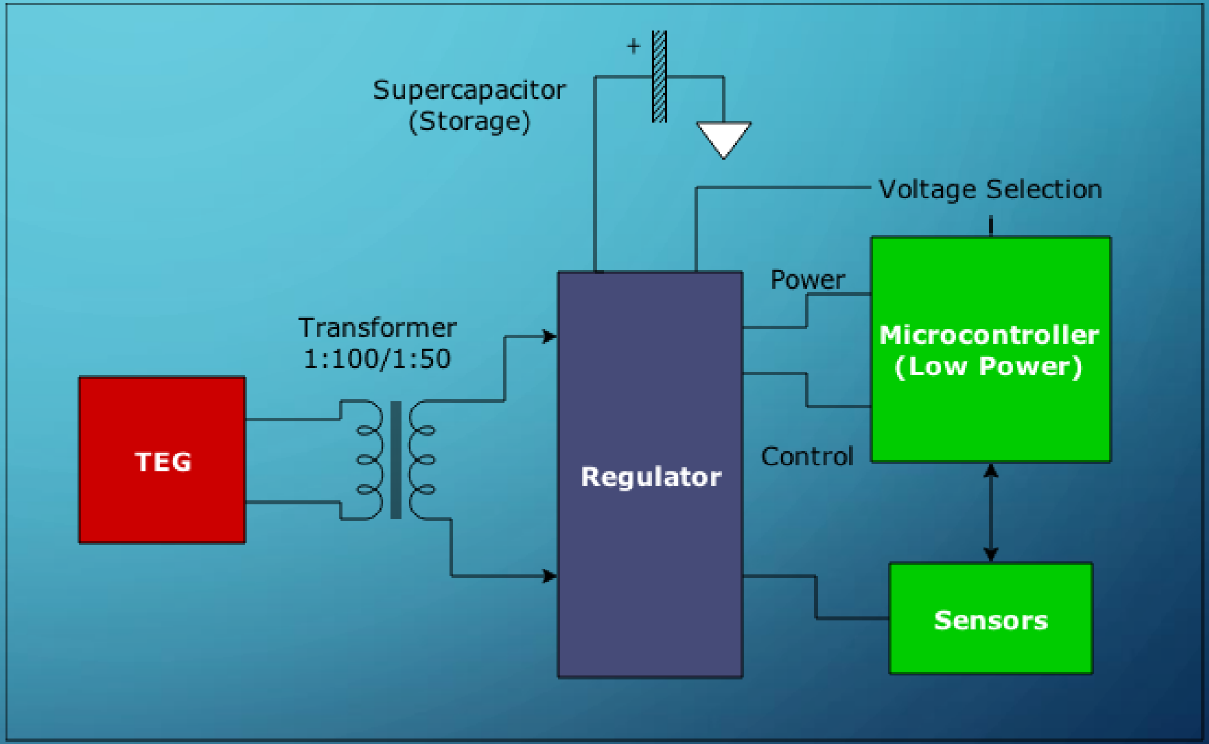
- This project studied the effectiveness of thermoelectric energy harvesting techniques in improving the runtime of small electronic devices attached to human body and reducing their dependence on external energy sources.

ENERGY HARVESTING SYSTEM:



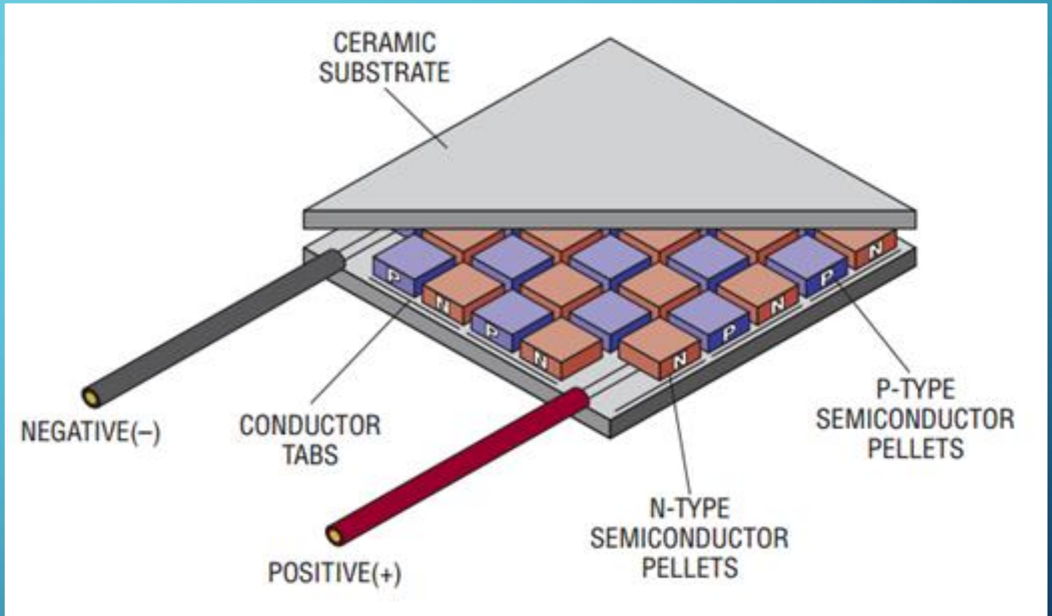
SYSTEM BLOCK DIAGRAM:

- Thermoelectric energy harvesting is based on converting a temperature difference into electricity using thermoelectric device (TEG)



THERMO-ELECTRIC GENERATOR TEG:

- TEG is a solid-state device which is used for heating or cooling.
- It converts a voltage difference applied to it into temperature difference between its hot and cold sides.
- When it is used for energy harvesting, the reverse process takes place and a temperature difference is converted into voltage difference.
- It made of a group of thermocouples connected electrically in series and thermally in parallel.



$V = \alpha \Delta T$

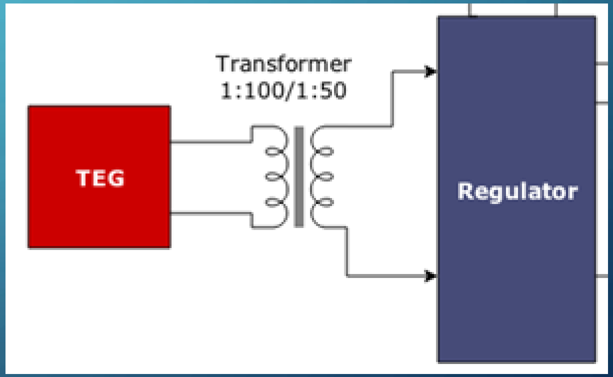
α: Seebeck coefficient

α= 100-300 μV/K

Bismuth-telluride Bi_2Te_3

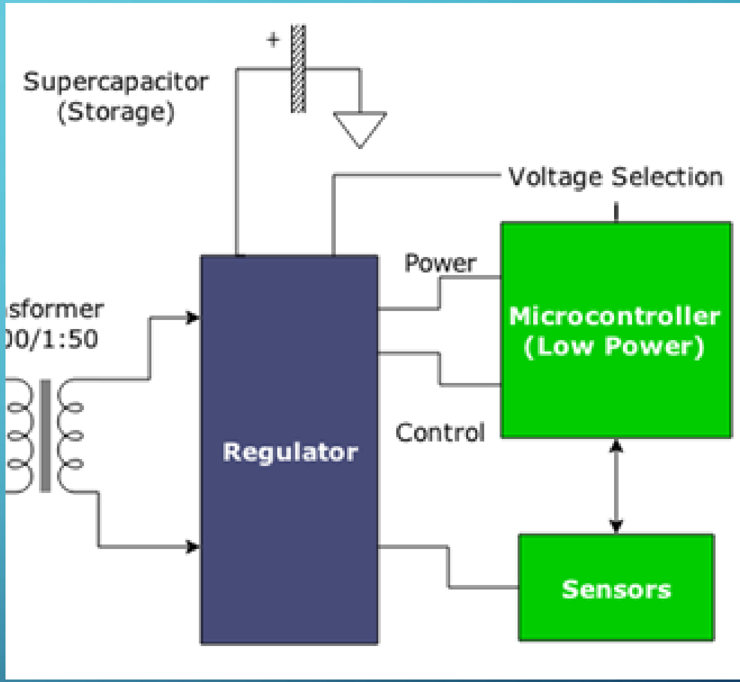
STEP-UP TRANSFORMER

- The transformer will raise the voltage produced by the TEG to allow the regulator to startup.
- Ratio 1:100 which allow the system to operate from 20-30mV input voltage



DC ENERGY REGULATOR:

- There is a recent advances in energy management circuits.
- It regulate the input voltage to produce voltages suitable to operate specific devices.
- It has several outputs at different voltages (2.35V, 3.3V, 4.1V, 5V)



SUPER CAPACITOR:

- It serves as our energy storage unit.
- They have long lifetimes compared to rechargeable batteries.
- It can withstand a huge amount of charging/discharging cycles.
- This storage is needed as a backup energy source in case the input source is not available.
- We used 0.1F 5.5V

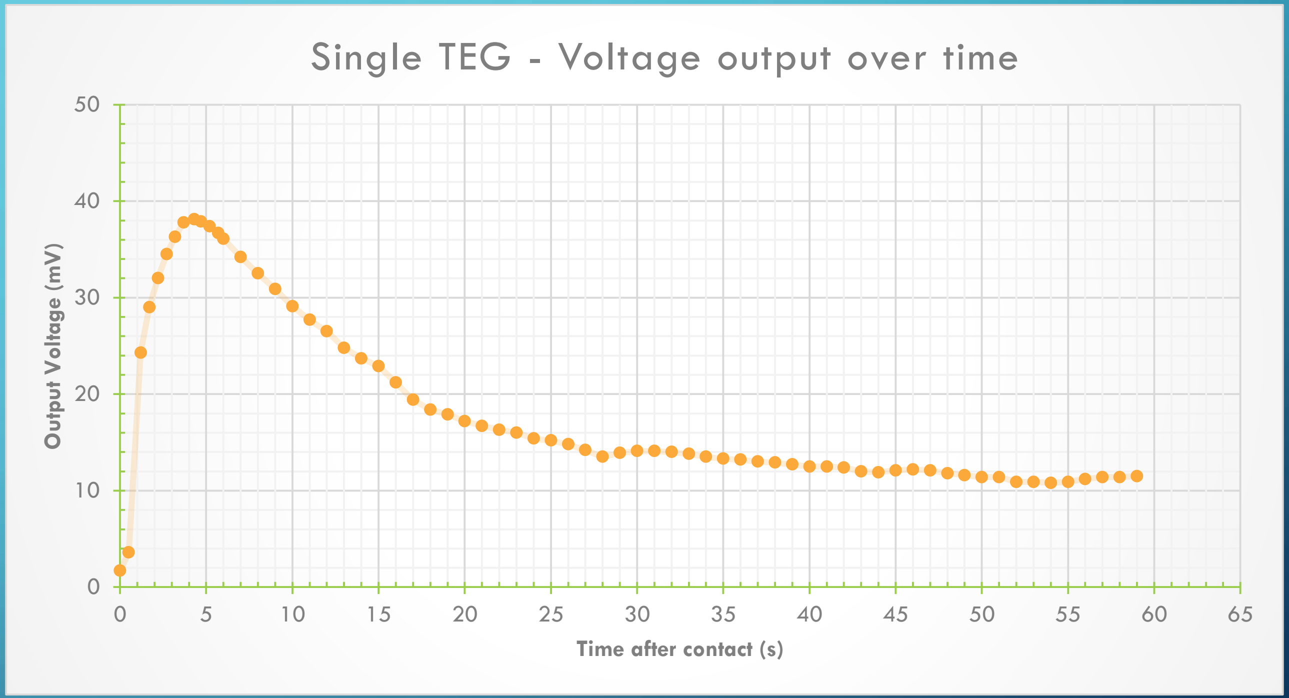
SYSTEM ANALYSIS: SINGLE TEG

- Fixed variables:

$T_A = T_C = 27°C$

$T_H = 34°C$ ($\Delta T = 7°C$)

- The TEG output reaches its peak value very rapidly, but does not continue providing that output for long. Its output starts to decrease exponentially, and levels off after a while.

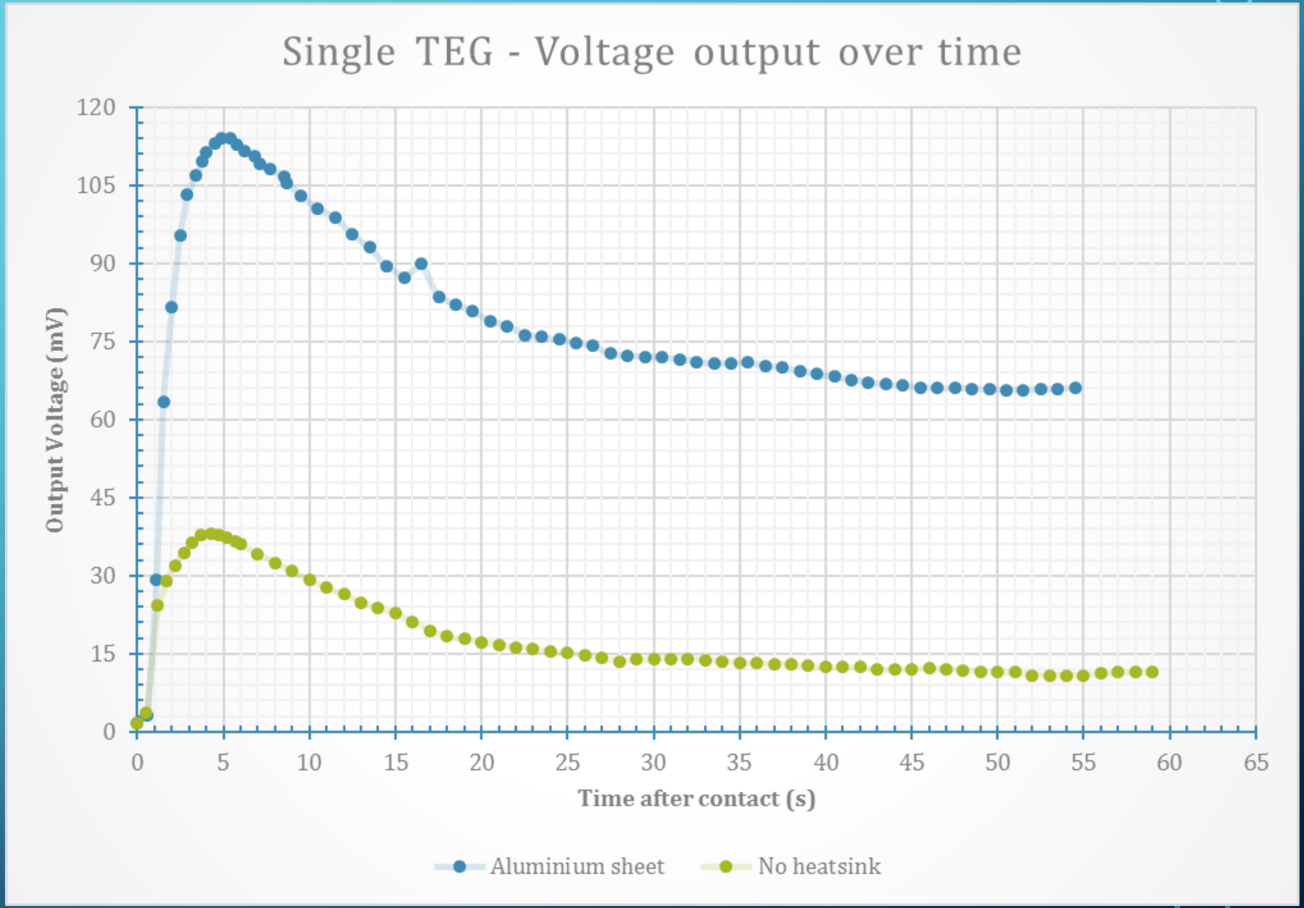


T_{peak} = 4.3 seconds
V_{peak} = 38.1 mV
$T_{settling}$ (2%) = 49 seconds
V_{final} = 11.5 mV
% Drop = 70%

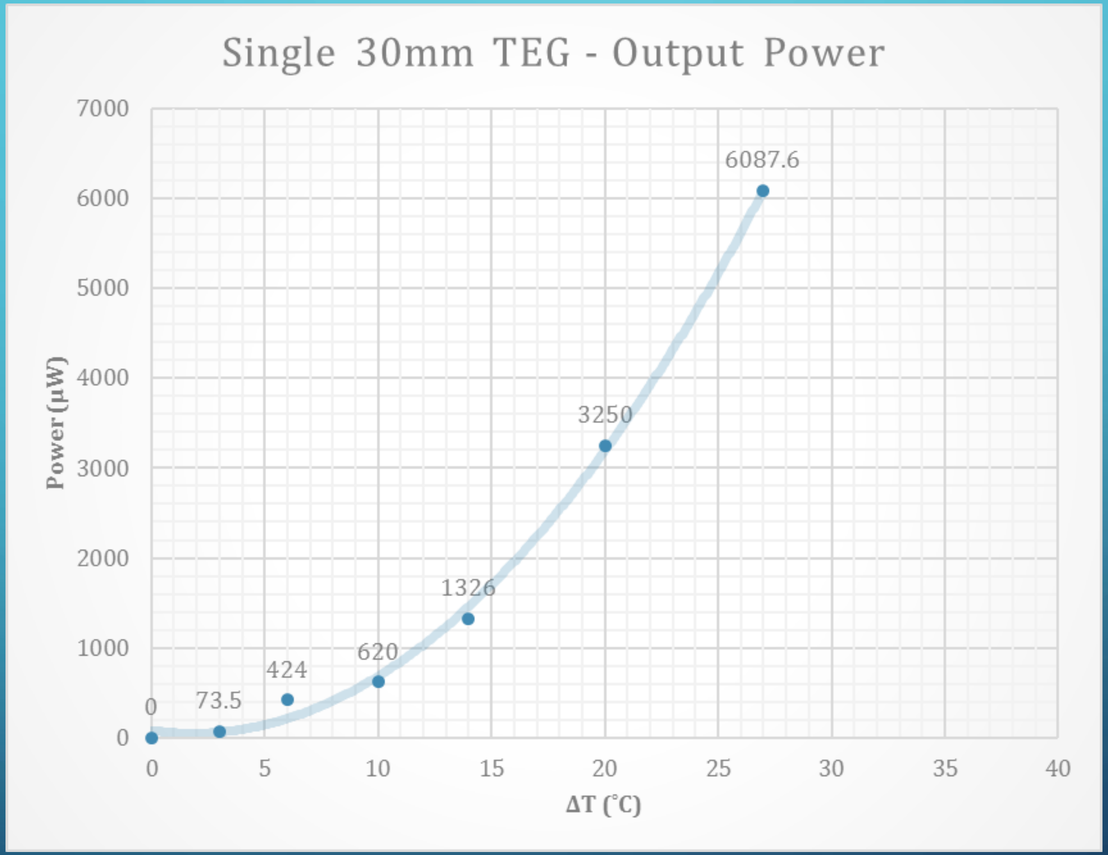
SYSTEM ANALYSIS: SINGLE TEG WITH HEAT SINK

	Configuration 1 (Green Graph)	Configuration 2 (Blue Graph)
Type of Thermal Management	No heatsink, cold side directly exposed to air.	Cold side in contact with aluminum sheet, acting as a heatsink exposed to air.
T_{peak} (s)	4.5	5.0
V_{peak} (mV)	38.1	114.1
$T_{settling}$ (2%, s)	49	42.5
V_{final} (mV)	11.5	66.0
% Drop	70%	42%

- Adding a heatsink in contact with the cold side of the TEG can drastically improve the performance of the TEG.
- The peak output voltage increased by 200%, the output settling time decreased by about 7 seconds, and the drop from the peak to the steady-state voltage went down from 70% to 42%.



SYSTEM ANALYSIS: ΔT VS OUTPUT POWER



CONCLUSION:

- Effectiveness: utilizing temperature difference between human body heat and air gives good results for small electronics devices.
- The system can produce (0.1mW-0.8mW) depending on the temperature difference.
- E.g hearing aid which has an average power consumption of 1.6mW
- Quality: The system excels in lifetime since all components used are rated to last for 5 years of usage (45000 hours) under certain operated conditions (-10˚C-50˚C, waterproof).
- Small in size.
- The efficiency is measured by applying certain temperature difference to TEG and comparing the output power with previous results, it is found to be 40%

Thank you