



# **Design and Fabrication of Energy Harvester by Using Fluttering Phenomenon**

By

**Eng. Ahmed Fathy Shabaan Abd Allah**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
In Partial Fulfillment of the  
Requirements for the Degree of  
**MASTER OF SCIENCE**  
In  
**MECHANICAL DESIGN AND PRODUCTION ENGINEERING**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
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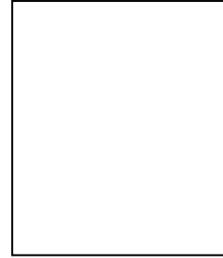
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**Title of Thesis:**

Design and Fabrication of Energy Harvester  
by using Fluttering Phenomenon

**Key Words:**

Energy harvesting; electromagnetic induction; windbelt, fluttering phenomnon.

**Summary:**

The objective of this study is to convert wind energy into electrical power. A mechanical vibrations generates due to fluid-structure interaction between airflow and belt. A Permanent magnet and copper coil are used to harvest electrical power from the mechanical vibrations of flexible belt which fixed on it magnet. A strong magnet is used to increase the power. A parametric analysis have been studied to analyze the effect of each design parameter on the harvester performance.

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To my dear Brother and my dear parent for their encouragement, endless support and ceaseless love, since the time I came to this world crying, I need badly to say, “Thank you. You’ve offered an overwhelming support of my well-being”.

## NOMENCLATURE

$B_r$	Electro-magnetic flux
$b$	Width of fluttering belt
$C$	is the velocity of wave propagation
$C_\alpha$	rotational damping coefficient
$C_h$	vertical damping coefficient
$C_L$	Lift coefficient
$C(k)$	derived function for the reduced frequency
$D$	Drag force
$d_i$	Coil inner diameter
$d_o$	Coil outer diameter
$d_w$	Coil wire diameter
$D_{em}$	coefficient of electromagnetic damping
$E$	Modulus of elasticity
$f$	structure flutter frequency
$f_c$	copper filling factor
$F_{em}$	electromagnetic force
$h$	Vertical displacement of belt
$h_c$	Coil height
$H_i$	flutter derivative coefficient
$I$	section polar moment per unit length
$i$	Electric current
$K_\alpha$	rotational stiffness coefficient
$K_h$	vertical stiffness coefficient
$L$	vertical aerodynamic lift force
$L_C$	Coil inductance
$L_w$	Length of wire
$L_b$	Length of fluttering belt
$M$	aerodynamic pitching moment
$m$	mass of belt per unit length
$N$	Number of coil turns
$R_C$	Coil resistance
$R_L$	Load resistance
$T$	Belt tension
$t_b$	Thickness of belt
$t_m$	Thickness of magnet
$U$	Mean air velocity

$V$	Voltage drop across the load resistance
$V_r$	reduced wind velocity
$V_T$	Volume of coil
$\alpha$	angular displacement
$\delta$	gap distance between coil and magnet
$\rho_{air}$	Air density
$\zeta_h$	critical damping ratio

## ABBREVIATION

AFM	Atomic Force Microscope
WBEH	Wearable Biomechanical Energy Harvesting
PVDF	Polyvinylidene fluoride
CFD	Computational Fluid Dynamic
FEA	Finite Element Analysis
FSI	Fluid Structure Interaction
mf	Magnetic Field
IVP	Initial Value Problem

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