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Conceptional designs of the rotation mechanism with antiphase energy harvester

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Table of Contents

Introduction

Background:

Use energy harvester to replace the battery.

- Increased demand for wireless sensors.
- Convert the slow rotational of any mechanical device which move in an unidirectional up-down motion.

Propose:

The concept design of a rotational antiphase vibration energy harvesting through experiment is proposed. It will also focus on the effect of the springs at different locations and the speed variation that affecting the voltage output.

Working Principle

- Ultilise the rotation to generate the vibration through the repulsive magnetic force.

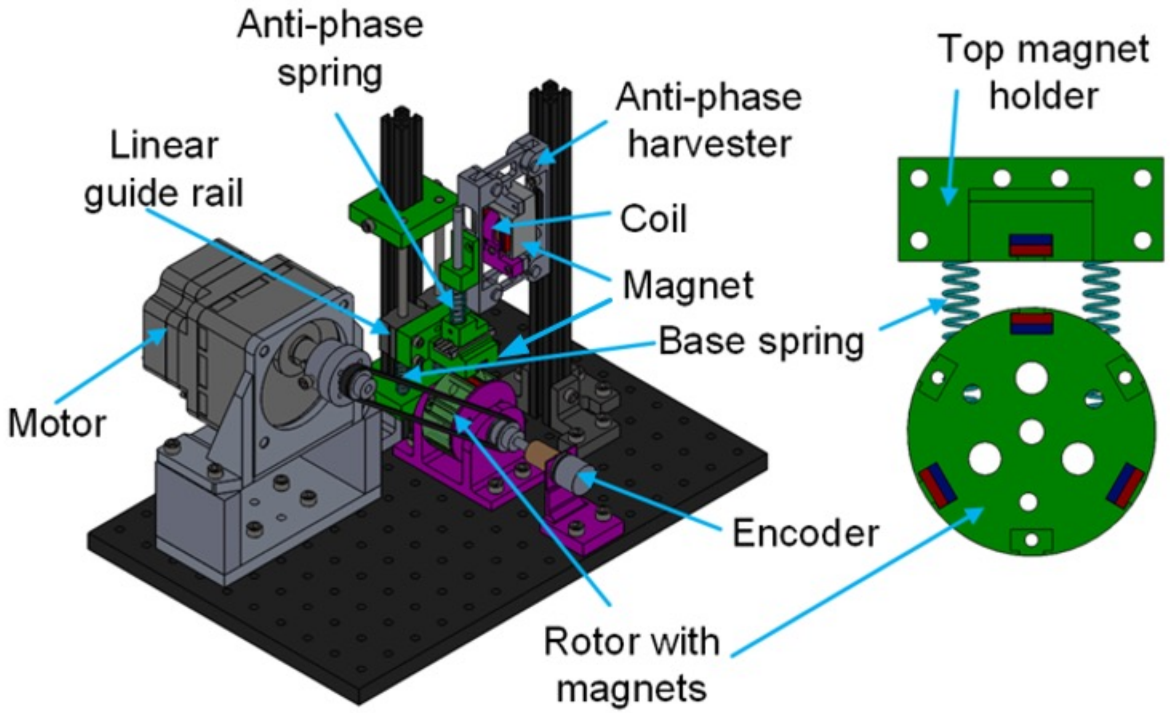

Figure 1. 3D model of the rotational energy harvester (left) and rotor with magnets and top magnet holder (right)

Experiment Setup

- Spring position sets that affected the power harvested
- Four configurations:
  1) TBS (top bottom springs)
  2) TS (top spring)
  3) BS (bottom spring)
  4) NS (no spring)
- Rotate speed: 200 rpm until 4,000rpm

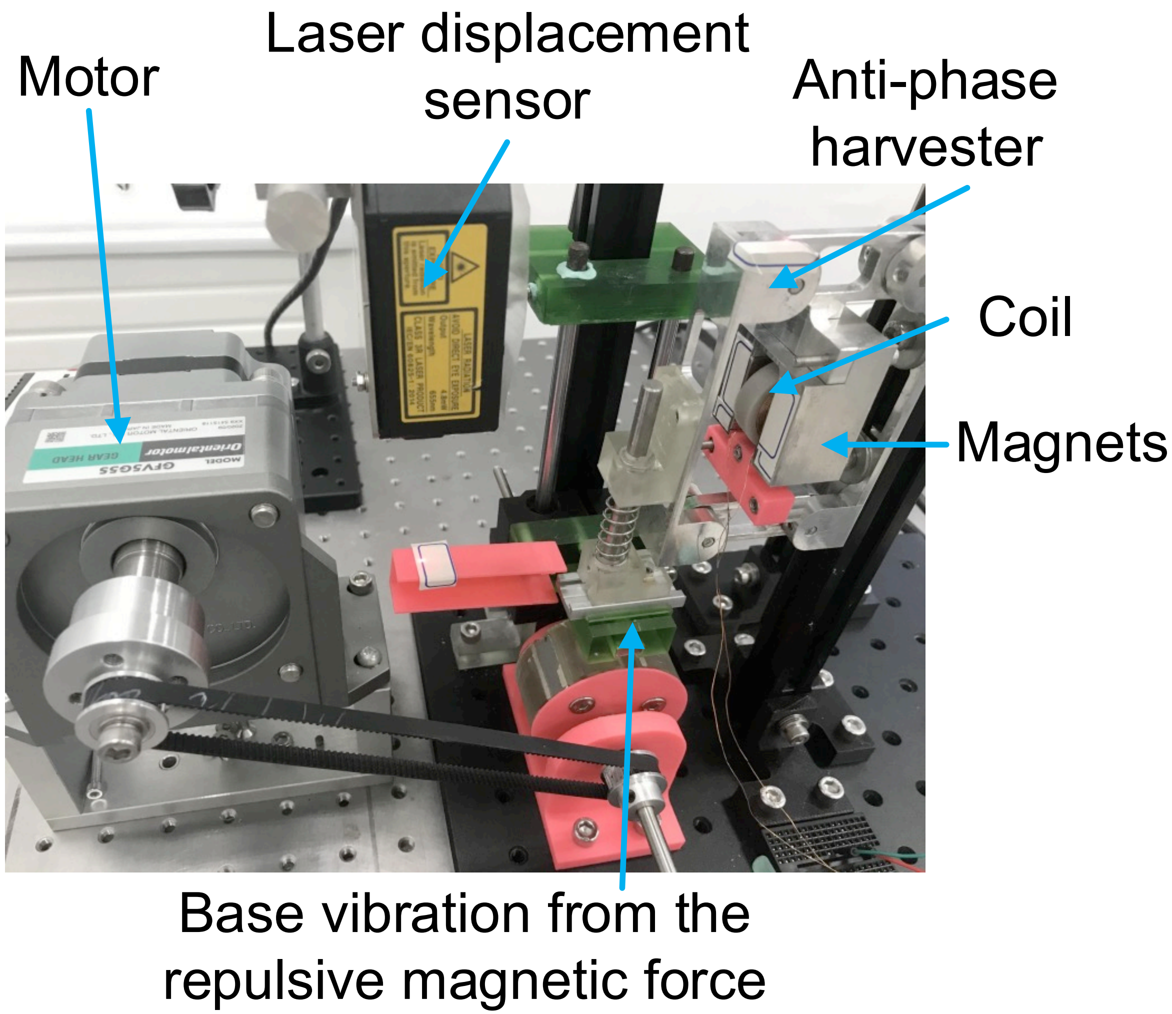

Figure 2. Experiment setup of the rotational anti-phase energy harvester

Experimental Results

- 3 equally space permanent magnets

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- 3 repulsive vibration in one revolution

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Key parameters of axis label
- Voltage
- Rotation frequency
- Base and anti-phase amplitude

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- Voltage – frequency graph
- Base amplitude – frequency graph
- Anti-phase amplitude – frequency graph

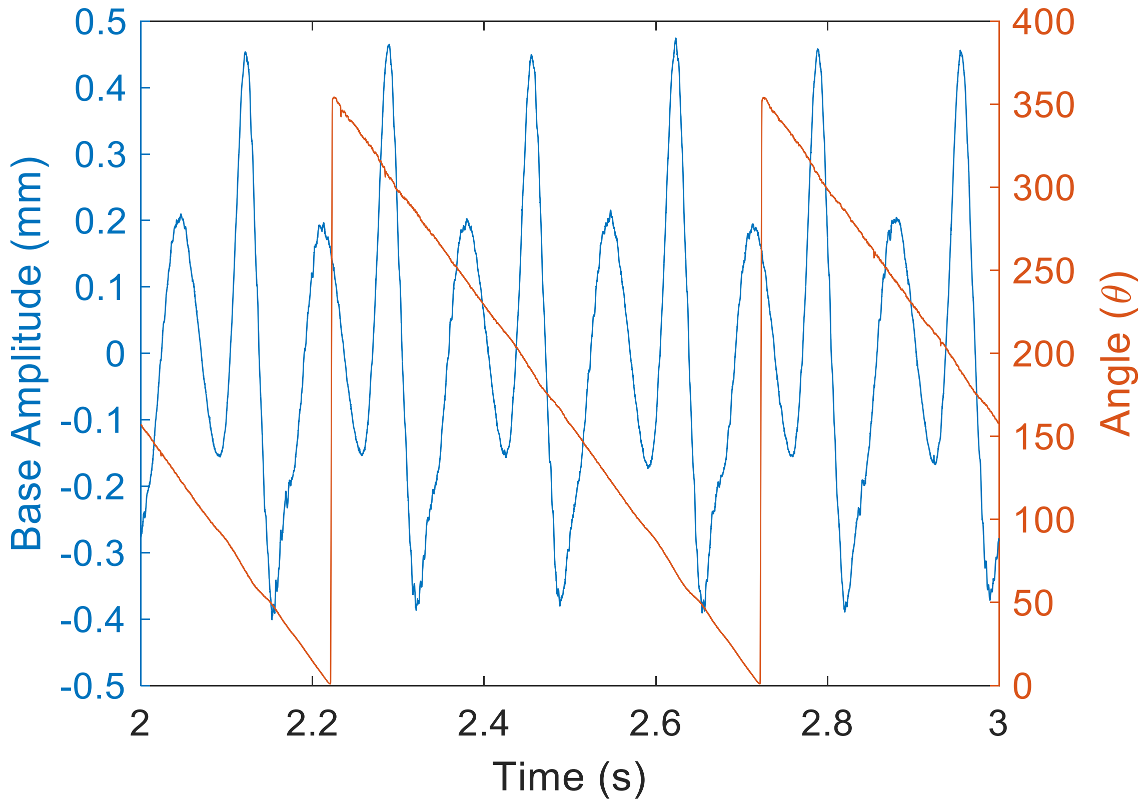

Figure 3. Time response curves of absolute base amplitude and angle for complete revolutions for D1 – TBS at 600 rpm

Experimental Results

Peaks = Maximum Altitude = Resonance

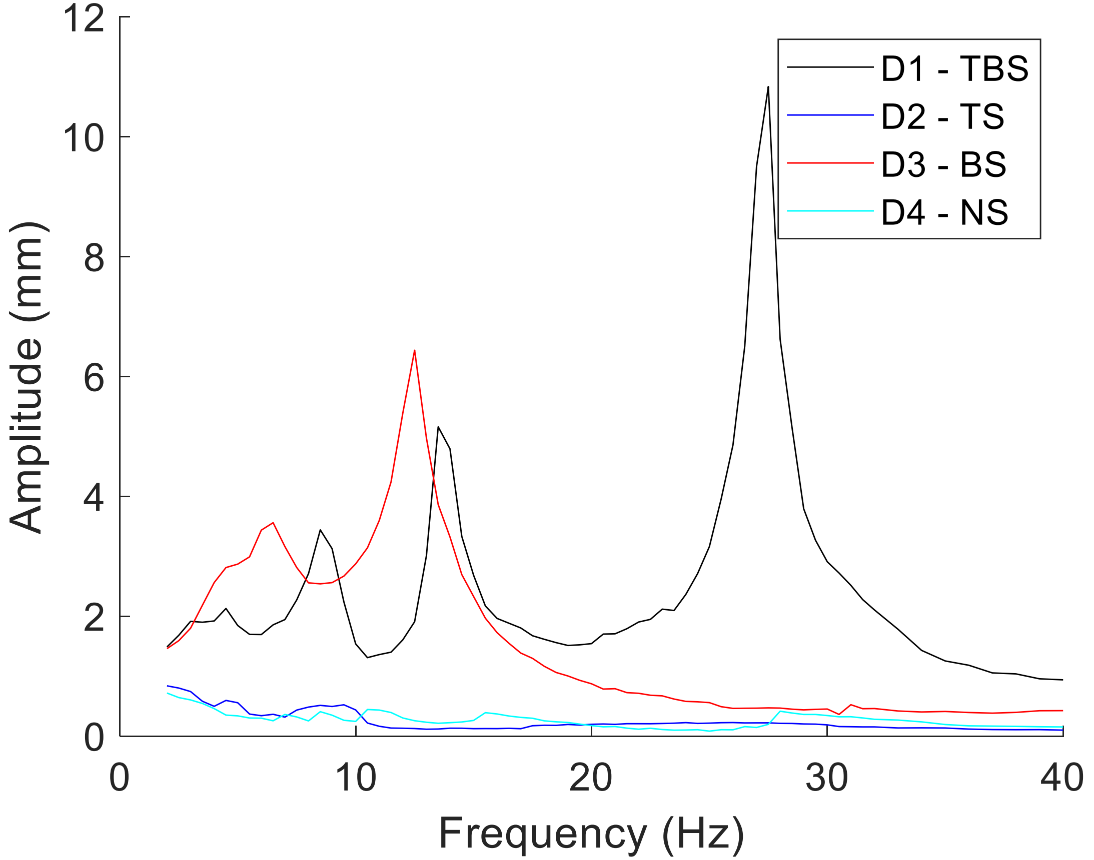

Figure 4. Absolute base amplitude designs 1 to 4 configurations

Design	Frequency (Hz)	Max Amplitude (mm)
D1 – TBS	8.5	3.44
	13.5	5.16
	27.5	10.83
D2 – TS	No clear peak	
D3 – BS	6.5	3.56
	12.5	6.43
D4 – NS	No clear peak	

- D1 and D3 could generate relatively obvious resonance when considering the base vibration.
- The performance of bottom spring configuration is better than both spring configurations at low-frequency range, i.e. 0 – 13 Hz.

Experimental Results

Peaks = Maximum Altitude = Resonance

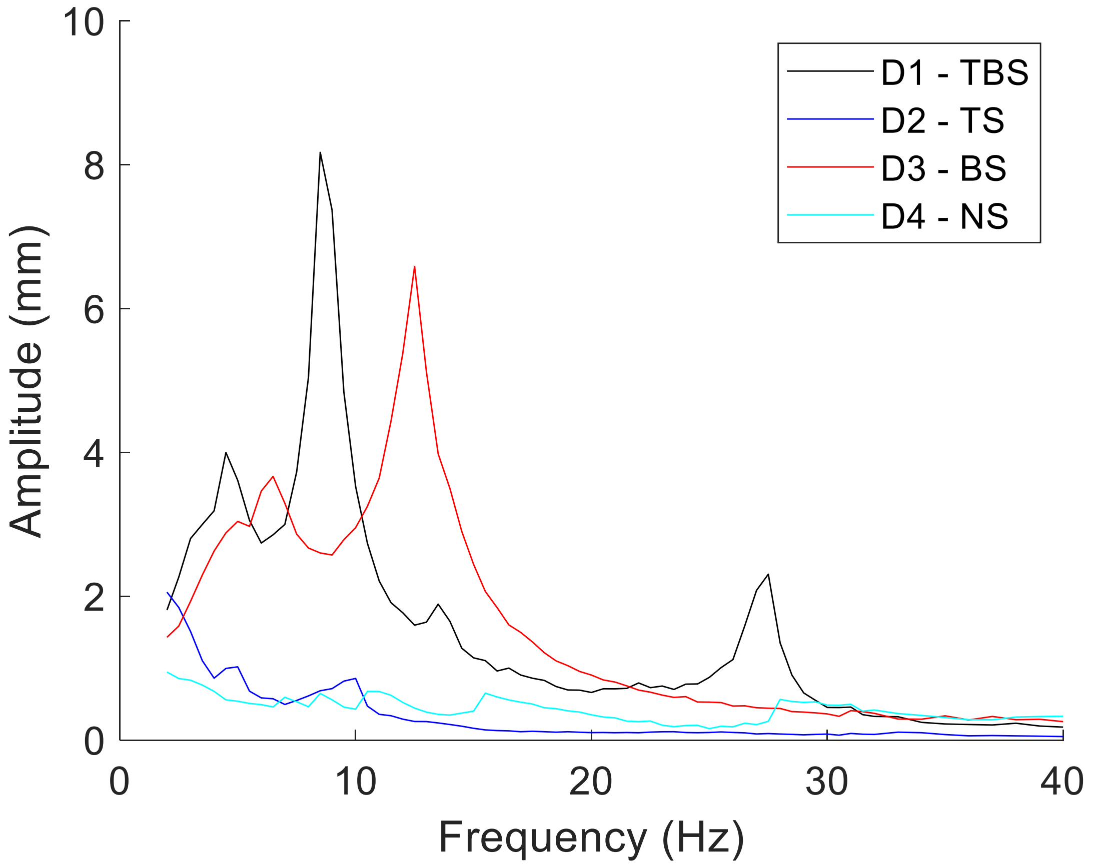

Figure 5. Absolute amplitude at antiphase for designs 1 to 4 configurations

Design	Frequency (Hz)	Max Amplitude (mm)
D1 – TBS	4.5	4
	8.5	8.17
	27.5	2.31
D2 – TS	No clear peak	
D3 – BS	6.5	3.67
	12.5	6.58
D4 – NS	No clear peak	

- The resonance performance of D1 is generally better than other designs when the frequency is lower than 10 Hz and larger than 21.5 Hz.
- The D3 takes advantage when the frequency is between 10 and 21.5 Hz.

Experimental Results

Peaks = More Energy = More Effective

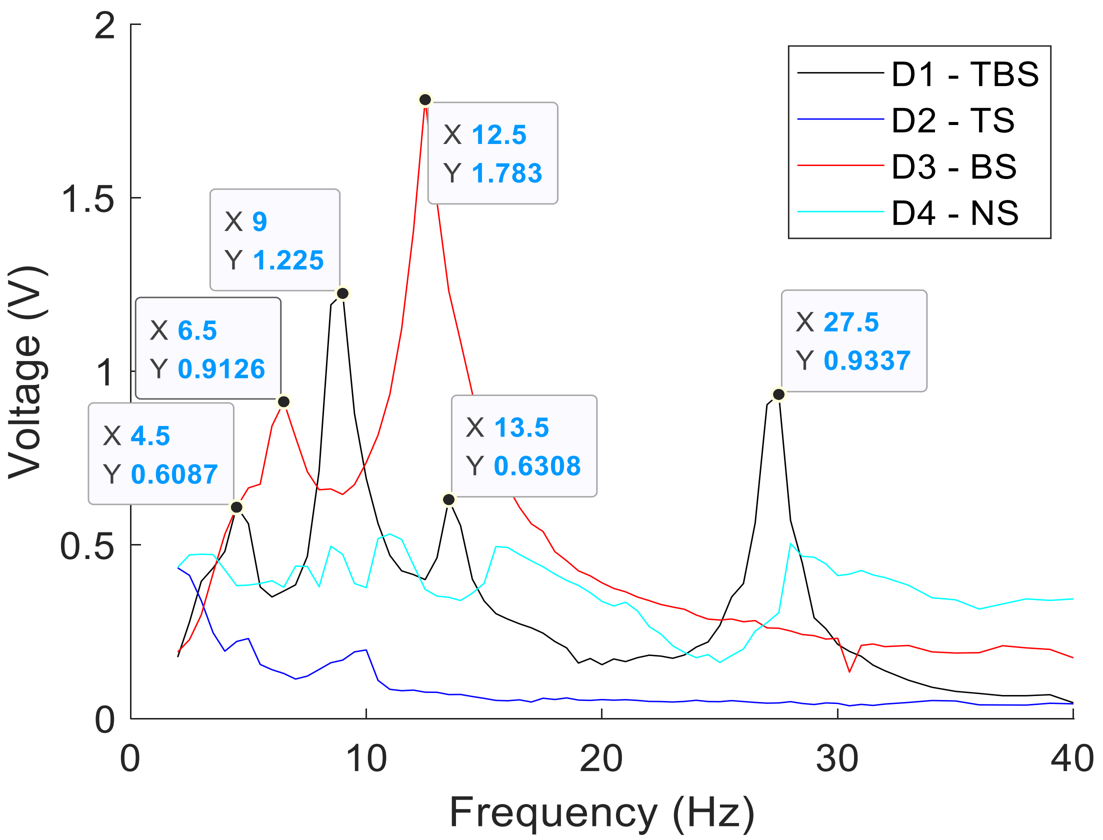

Figure 6. Voltage versus frequency for designs 1 to 4 configurations

Design	Frequency (Hz)	Max Voltage (V)
D1 – TBS	4.5	0.61
	9	1.23
	13.5	0.63
	27.5	0.93
D2 – TS	not contributing to the enlargement of electricity generation	
D3 – BS	6.5	0.91
	12.5	1.78
D4 – NS	Fluctuation and 0.5 V on average	
	Voltage drop at 25 Hz	

The average voltage of D1 is generally lower than D3 for almost all the frequency range between 0 and 40 Hz except for 10 Hz and 27.5 Hz where two voltage peak occurs

Conclusion

- The bottom spring has a significant effect on the amplitude and voltage amplification, but the top spring might contribute inversely and impact the performance to some extent.
- However, the combination of top and bottom springs can produce a better performance at a certain frequency range.
- The proposed concept designs are useful for the wireless sensor nodes to provide continuous power for the sensors to operate.

Future Works:

The experiment can be improved with multiple materials that have better magnetic flux for the design of the rotation part.

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Thank you.