HARVESTING NONLINEAR VIBRATION WITHIN HIGH G ROTATIONAL SYSTEMS

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Introduction

- Legislations in recent years have made it mandatory for new cars in the EU and US to have tire pressure sensors [1].
- This motivates higher need for autonomous sensors powered by energy harvesters [2].
- The centripetal acceleration observed in automotive wheels can reach several thousand g's.
- High amounts of centripetal acceleration manifests as a strong artificial gravitation field and may supress the oscillation of linear oscillators [3].
- This study intends to utilise the artificial gravity induced non-linear vibration to increase the amount of energy harvested in high g rotational environments [3].

Experimental device

- A modified 140mm computer fan is being used to hold a piezoelectric cantilever (Figure 1)
- The device uses a bespoke cradle to hold a piezoelectric cantilever
- The cradle has been designed so that the cantilever is attached to the radial axis with the mass pointing towards the centre of rotation
- Copper strips are being used as commutators to allow power readings to be taken
- The mounting of the fan has been made using aluminium and carbon fibre to reduce weight
- A second cradle has been installed without a piezo device to keep the system rotationally balanced

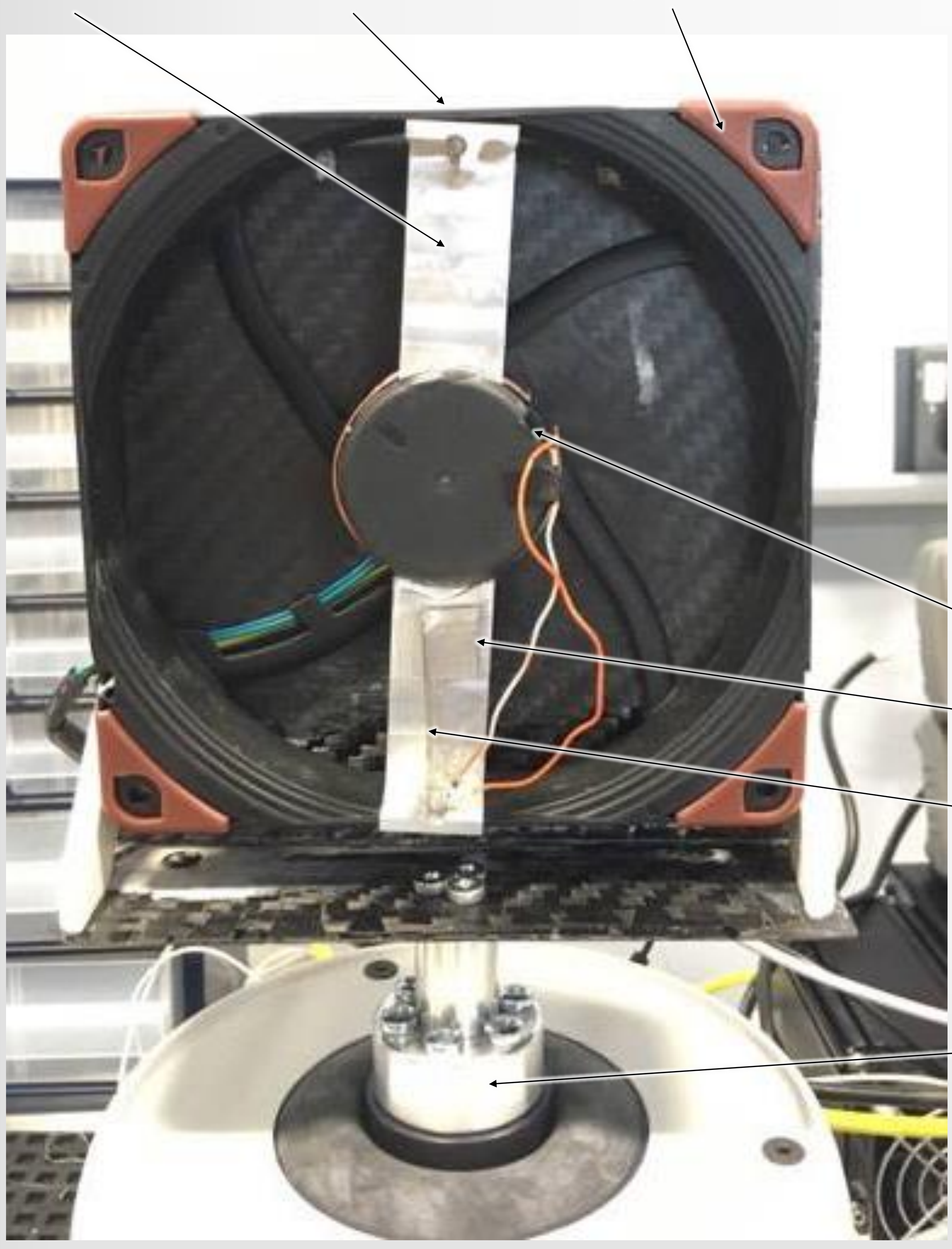

Figure 1: Modified 140mm fan

Full setup

- The computer fan is controlled by varying the voltage through a DC supply
- The fan rotation is initiated at 5 V and reaches 3000 RPM at 12 V.
- At full speed the mass experiences around 500g as per $\omega^2 r$.
- The speed of the fan is monitored using the on-board tachometer in an Arduino Uno
- Data from the Arduino can used to calculate the forcing conditions subjected to the piezoelectric cantilever oscillator.
- A mechanical shaker is used to experimentally simulate ambient vibration.
- The device can be mounted vertically (as pictured) or horizontally on the shaker
- The shaker is controlled by a function generator and a power amplifier
- The signal from the piezoelectric device is recorded on an oscilloscope.

Methodology

- Investigation of 6 different scenarios:
  - Vertically mounted, shaker running, rotating
  - Vertically mounted, shaker running, no rotation
  - Vertically mounted, shaker off, rotating
  - Horizontally mounted, shaker running, rotating
  - Horizontally mounted, shaker running, no rotation
  - Horizontally mounted, shaker off, rotating
- Experiments conducted with various signals to increase the yield of the energy harvester
- Initial signals use the natural frequency of the device

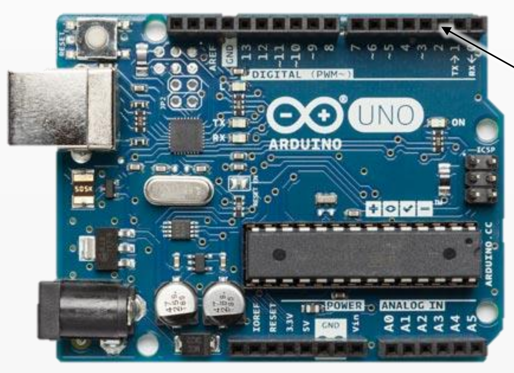

Figure 3: Arduino Uno. Source: https://www.arduino.cc

- Non-linear vibrational phenomena is being investigated to overcome the suppressive effects of the high g environment
- Application of vibration control allows various scenarios to be explored to interrogate potential improvement in high g environments

Conclusion

- This study lays the basis for establishing a theoretical framework to devise a new type mechanical amplifier in rotational systems.
- This novel mechanical amplifier can be used to design more efficient vibration energy harvesting solutions in rotational systems.

References

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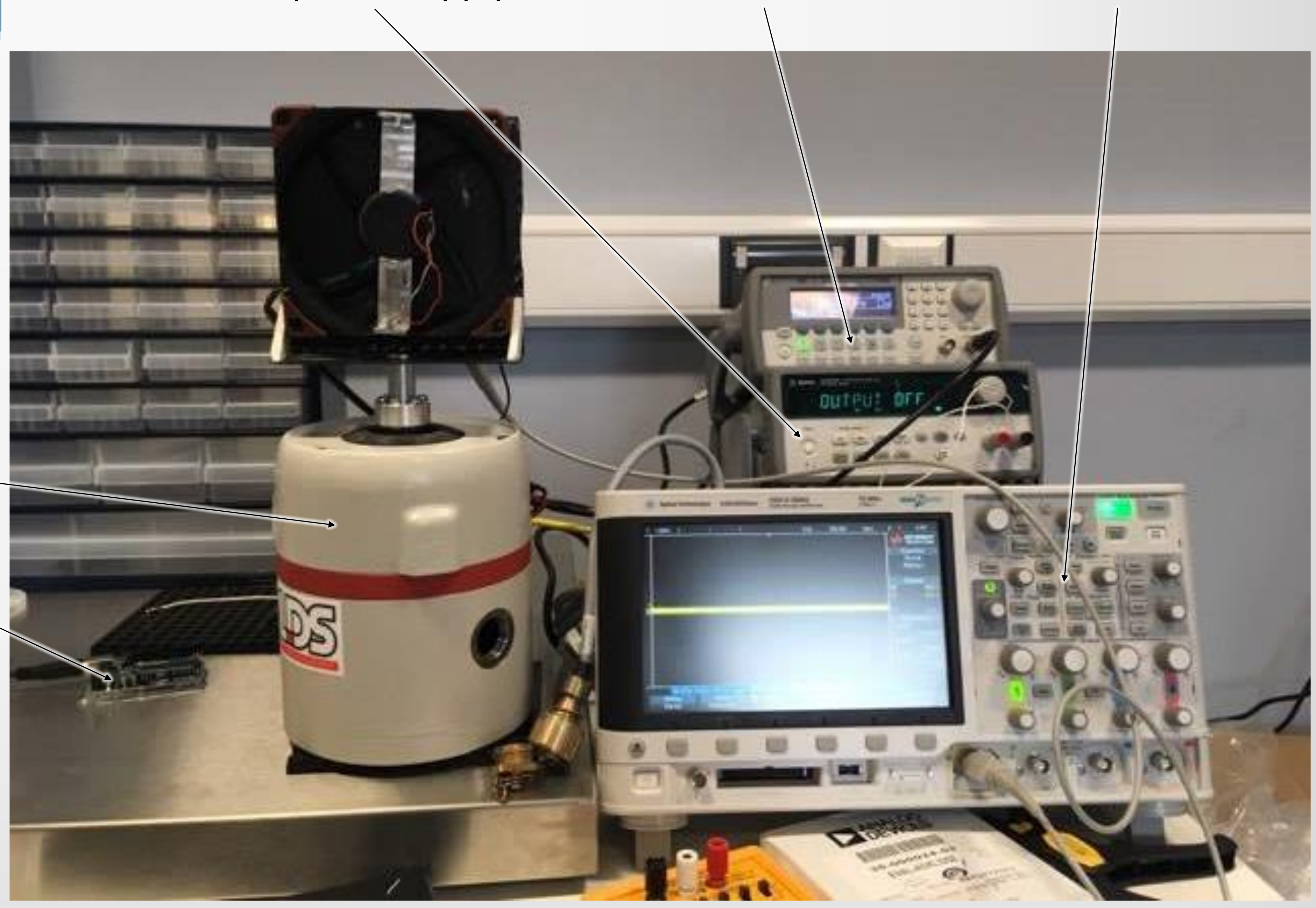

Figure 2: Full experimental setup