Watt’s Linkage based large-band low-frequency sensors for scientific applications

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Goal: implementation of very effective one-dimensional mechanical sensor for the implementation of uniaxial (horizontal and/or vertical) and modular triaxial seismometers and accelerometers for ground, space, and underwater applications, including ultra-high vacuum and cryogenic ones.

Solution: UNISA Folded Pendulum - Patents: 1394612, 1405600 (Italy), 5409912 (Japan), 2518587 (Russia), 2010269796 (Australia), 8,950,263 (USA) - Europe, Japan, Russia, Australia, USA, Canada pending.

Scientific Applications: displacement, velocity and acceleration sensor for large band low-frequency monitoring and control for standard and critical applications (ultra-high vacuum, cryogenics, hostile environments, etc.) fully tunable in terms of performances and cost to the specific application.

\textbf{Horizontal Monolithic Seismometer/Accelerometer (2015)}

\textbf{Triaxial Modular Monolithic Seismometer/Accelerometer (2015)}

\textbf{UNISA FOLDED PENDULUMS PERFORMANCE RANGES:}

- Band: 0.0001 mHz < B < 1 kHz
- Directivity: > 10^4
- Resonance Frequency: 50 mHz < f_0 < 1 kHz
- Sensitivity: 10^{-15} m/Hz^{1/2} < S < 10^{-6} m/Hz^{1/2}
- Quality Factor: Q > 16000 in UHV - Q > 2000 in air
- Scalability

Modular Readouts: shadow meter, optical lever (PSD, quadrant photodiode), laser interferometer, optical fibre bundle, LVDT, capacitive sensor

\textbf{VIRGO Baffles Monitoring (2014)}

- Band: 40 Hz < B < 1 kHz
- Directivity: > 10^4
- Res. Freq.: 5 Hz
- Size: 8.5 cm x 7.8 cm x 4 cm
- Weight: 200 g
- Sensitivity: 10^{-13} m/Hz^{1/2}
- Readout: LVDT

\textbf{Seismic Sensor (Sos Enattos) (2013)}

- Band: 10^8 Hz < B < 102 Hz
- Directivity: > 10^4
- Res. Freq.: 200 mHz
- Size: 14 cm x 13.4 cm x 4 cm
- Weight: 1200 g
- Sensitivity: 10^{-13} m/Hz^{1/2}
- Readout: LVDT

\textbf{SENSITIVITY CURVES}

\textbf{ACTIVE APPLICATIONS AND COLLABORATIONS (UNIAxIAL AND TRIAXIAL MONOLITHIC UNISA FOLDED PENDULUM)}

- Geophysics: seismic noise monitoring for low frequency characterization 10^{-8} – 10^{-2} of the Sos Enattos Mine (Lula) in Sardinia.
- Historical Heritage: real-time low frequency monitoring of relevant Italian monuments for structural characterization and conservation.
- Bridges Safety: real-time low frequency monitoring of bridges for structural analysis and safety.
- Science: Virgo baffles monitoring for correlation with output detector signal.
- Measurement of the sensitivity curve in closed loop configuration.

\textbf{IN PROGRESS}

- 20 mHz UNISA Folded Pendulum for geophysical applications.
- Deep underwater (4 km) microphone for scientific applications.
- Accelerometer for Newtonian noise measurement.
- Open loop accelerometer for multi-stage seismic attenuation control system.

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