Development and Assembly of a MEMS Based High-Sensitivity Relative Gravimeter for Multi-pixel Imaging Applications

K Toland[1], A Prasad[1], K Anastasiou[1], R Middlemiss[1,2], A Noack[1], D Paul[2] and G Hammond[1]
[1] Institute for Gravitational Research, University of Glasgow, [2] James Watt School of Engineering, University of Glasgow

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Wee-g

Developed at the University of Glasgow (UofG) [1], Wee-g, shown in figures 1 and 2, is a MEMS based high-sensitivity relative gravimeter for use in a variety of areas, such as multi-pixel imaging and point measurement surveying. Utilising techniques from the gravitational wave field [2], a proof mass is suspended in a geometrical anti-spring configuration, allowing for resonant frequencies <10Hz to be observed. Displacement of the proof mass is measured through capacitive sensing techniques. The Wee-g is housed within a thermally controlled nested enclosure, where temperature is controlled to 0.2mK around the MEMS device allowing for a sensitivity of 10μGal [3]. The outer casing housing the MEMS device and all of the internal components is an IP67 rated enclosure and in total weighs under 4kg to allow for outdoor use. Tilt adjustments of up to 5 degrees can be obtained through manual feet adjusters or remotely through stepper motors. The Wee-g device's electronics utilises a Field Programmable Gate Array (FPGA) and can be powered through either a mains power supply, or through a 12V battery pack, drawing 5-10W of power under nominal operation. Currently, there are over 20 channels to monitor the Wee-g, including 3 channels dedicated to the MEMS device, 8 temperature sensors, device tilt, humidity and pressure monitors. Multiple Wee-g devices will be installed on Mount Etna as part of the NEWTON-g gravity imager project in 2021 [4], as well as conducting gravity measurements in collaborations with the Quantum Technology Hub.

Figure 1: Prototype Wee-g devices that are currently being field tested.

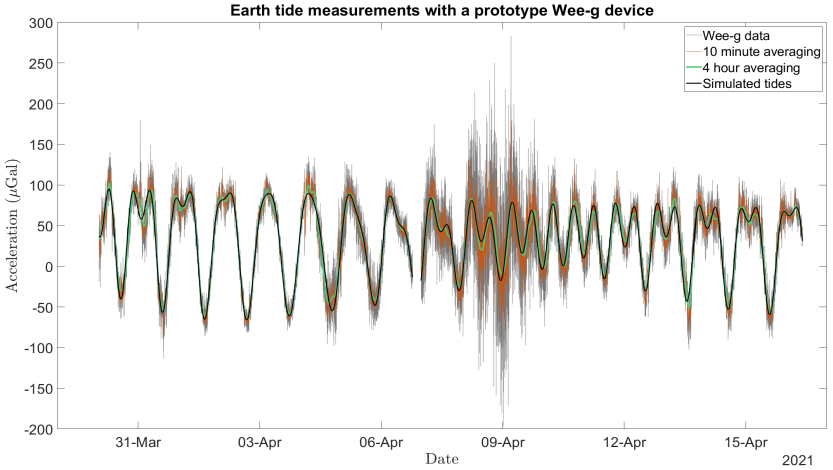

Figure 4: 17 day measurement of the Earth tide with a prototype Wee-g device.

Earth Tide Measurements

Prototype versions of the Wee-g have gone through various testing at the UofG. The prototype devices have shown to reliably track Earth tides in various environmental conditions, such as environmentally quiet/stable conditions, to environments exposing the prototype to outside temperature changes. Figure 4 shows a 17 day measurement of Earth tides, with the simulated tide overlaid. While in a non-turbulent environment, correlation coefficients of 0.958 can be achieved before averaging data with the simulated Earth tides.

Building surveying

The Wee-g prototype has been used to measure changes in gravity within the Physics department at the UofG. Measurements taken from the basement level to the top floor of the building is shown in figure 3, as well as measurements taken with a commercial gravimeter for comparison. A change of 5mGal can be observed for both devices between the basement and the 5th floor.

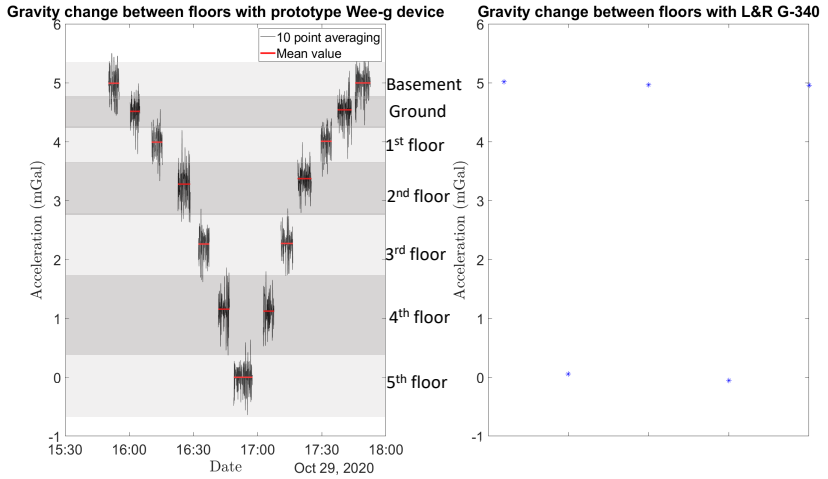

Figure 3: (left) Change in gravity between a total of 6 floors at the UofG using a prototype Wee-g. (right) Change in gravity between the bottom and top floor with a L&R G-340, taken in collaboration with Bridgeporth.

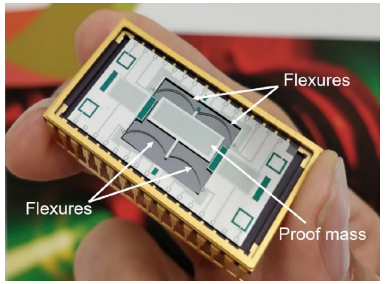

Figure 2: The MEMS gravimeter used in Wee-g.

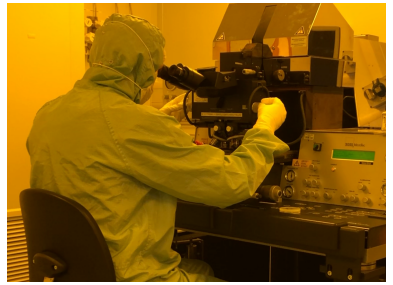

Figure 5: Assembly work is carried out within the JWNC at the UofG.

Assembly of Wee-g

Fabrication of the MEMS devices is carried out within the James Watt Nanofabrication Centre (JWNC) at the UofG, shown in figure 5. Manufacture of hardware components for the Wee-g device is currently being carried out in collaboration with Wideblue Ltd in Glasgow. Assembly and debugging of the system is also carried out at UofG.

Bibliography

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