SuperGen Blog-

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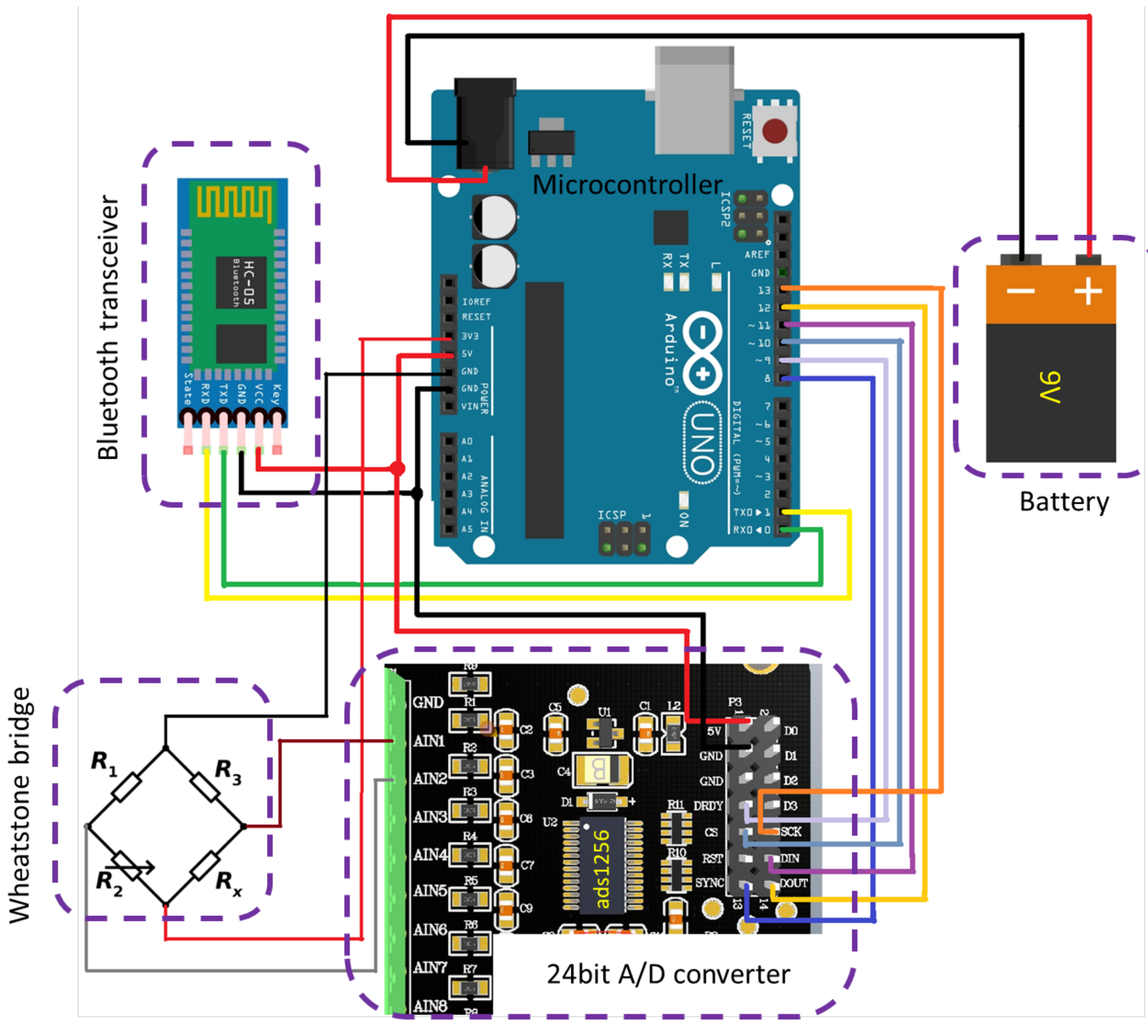
It is important to continuously monitor structural health, and make repairmen in the first instance of damage before such damage lead to a catastrophic structural failure. It has been reported that the replacement of a wind turbine blade costs several times than a rapid repairmen in the early stage of damage. Many techniques have been developed for structural health monitoring (SHM), however few of them have considered wireless communication, saying not being a standalone working system. A standalone SHM system is crucial to an offshore structure or a rotational machine, i.e. wind turbine that is difficult to approach.

Since the electrically conductive properties of graphene were reported, many research have been carried out to develop graphene-based sensor. The very common pathway is to monitor the electric resistance change of graphene due to the external stimulus, such as mechanical loading, thermal shock, and chemical reaction. In this pathway, a device must be carefully designed and attached to the structures being monitored. In this project, we are looking at different pathway in which the graphene (as sensor) is embedded inside the structure – it is part of the structure itself. Once the formation of damage causes an unusual change of electric resistance, a damage is identified. It is possible to locate the position of the damage if placing multiple probes. Therefore, the SHM system should be designed as a multichannel system.

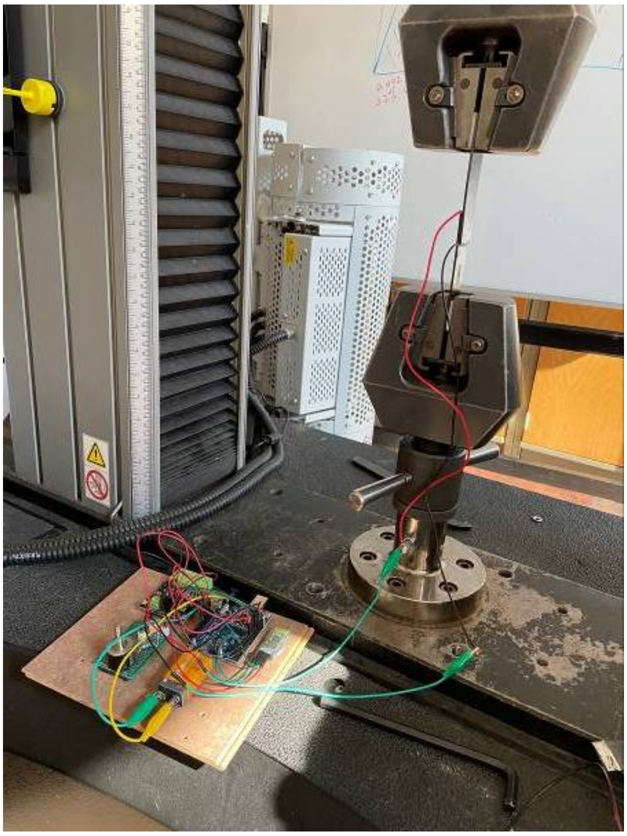
The graphene nanoplatelets (GNPs) based adhesive was developed at the University of Derby, while the wireless SHM system was developed at the University of Plymouth. The GNPs reinforced adhesive was fabricated by a solvent-free method, which combines mechanical mixing and ultrasonic bath. Different GNPs loading (0.25 wt% to 5 wt%) were tested to identify the electrical percolation threshold of adhesive. Two sizes of GNPs, namely $2\ \mu m$ and$25\ \mu m$, were tested. The tensile test of GNPs reinforced adhesive was performed to quantify the effects of GNPs on adhesive strength. The best configuration of GNPs reinforced adhesive, which offers high electrical conductivity, and good mechanical performance was selected to manufacture single lapped joints. Both carbon fibre and glass fibre epoxy joints were manufactured and sent to Plymouth for characterisation.

As this is a feasibility study to demonstrate the capacity of this wireless system, all components are commercial products – but they have the potential to be integrated as a single SoC (system on chip) which can be easily attached into a wind turbine blade. We have chosen Arduino as microcontroller because of the low power consumption and it is perfect companion of Bluetooth HC05 chip which acts as a wireless transceiver. The extremely low noise analogy to digital convertor (ADC), ADS1256 detects a small change of electrical signal of the GNPs reinforced adhesive. ADS1256 provides 8 channels and more channels are achievable if connecting multiple ADCs to the microcontroller. This wireless system has been calibrated with a commercial 6.5-digit benchtop multiplexer and such calibration along with the Arduino code have been published on GibHub, an open-source community.

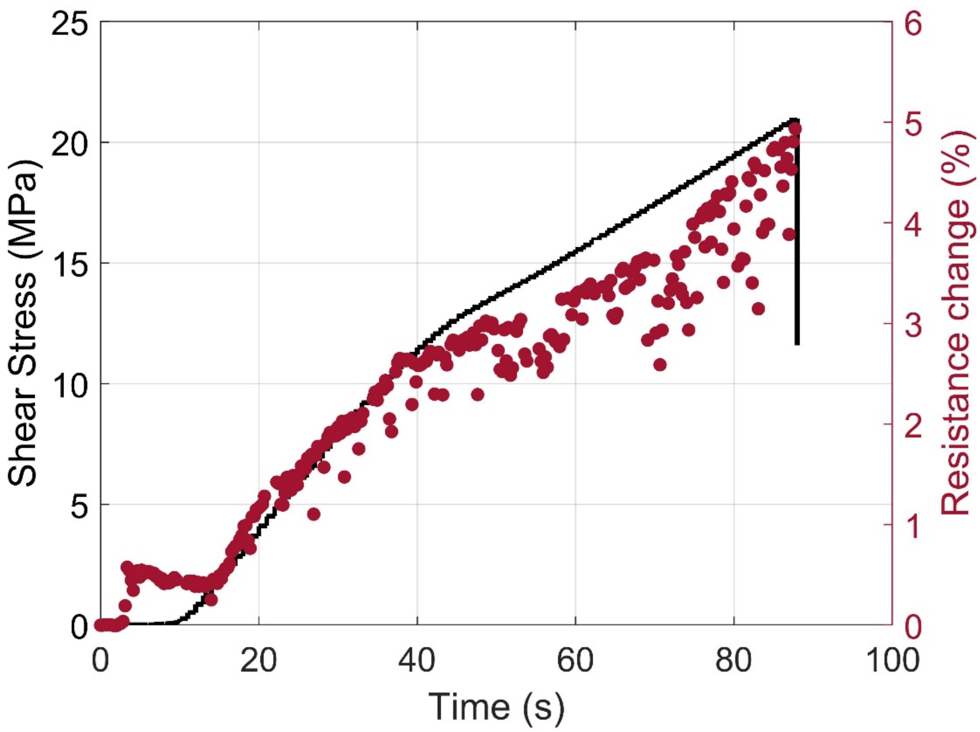
Due to the COVID lockdown and short of laboratory technician, the project has been significantly delayed. In the current stage, we have demonstrated that this wireless system works very well, and we are expecting to publish our work in an open access journal shortly. We are also expecting that this wireless system will help us to conduct research on SHM in the next few years.



The wiring diagram of the wireless system: Arduino Uno microcontroller, HC5 Bluetooth transceiver, ADS1256 ADC converter, Wheatstone bridge, power pack.



The mechanical testing of GNPs reinforced adhesive specimen. Electrical signal was detected, processed, and transmitted to a remote laptop.



The correlation of shear stress and the change of resistance in GNPs reinforced adhesive.