Results from the aeronautic use case being implemented in InComEss

The validation of the InComEss novel energy harvesting system in an aeronautic use-case scenario has been focusing on reclaiming the energy dissipated during flight operations, whilst addressing sustainable state variable monitoring in primary aerostructures. This leans on exploiting polymeric-based piezo-electric energy harvesters and low-energy consuming electric circuitry to advance monitoring of wing skin temperature conditions through fibre optical sensors and wireless data communication to an IoT platform.

Figure 1 shows a global view of the whole test setup, with indication and relative position of the main constituent items. The test validation focuses on adopting an InComEss cantilevered piezo-electric generator (PEG) as opposed to a lead-based commercial strain PEG for baseline comparison, which are both constrained to a shaker platform via interface tools. The harvested energy is distributed to a Printed Circuit Board (PCB), including an InComEss Power Conditioner Circuit (PCC) and a commercial supercapacitor for energy management and storage before being converged to photonic components (both an InComEss miniaturized interrogator and an FBG-engraved fibre optical sensor FOS) for data capturing and wireless communication via an InComEss IoT gateway. The FBG (bonded on a representative composite skin configuration) detects the through-the-thickness temperature gradients caused by the activation of a heater mat bonded on the skin, whilst the measurement is compared to that of embedded standard thermocouples.

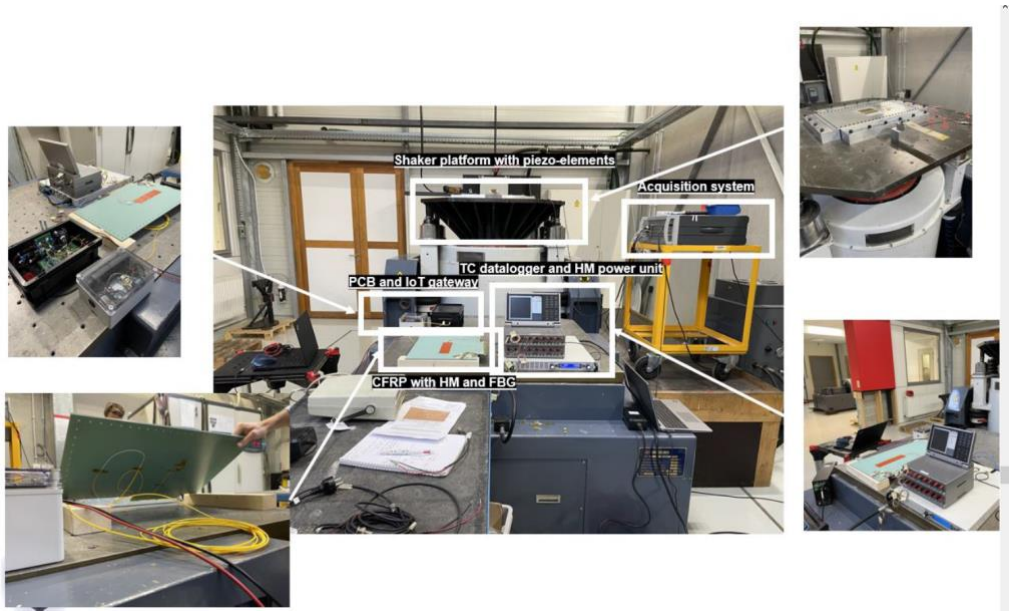

Figure 1. Overview on InComEss test setup for an aeronautic demo.

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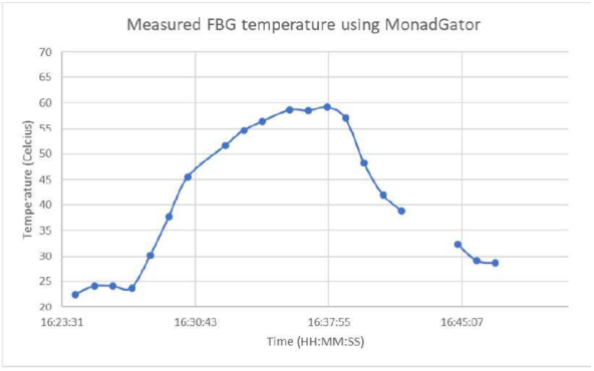
The test results evidence that the InComEss energy harvesting system could not demonstrate to close the loop in a cantilever PEG configuration. Although the InComEss cantilever PEG has been responsive to an external imposed sine vibration, the generated energy is insufficient to adequately feed the downstream circuitry (likely ascribable to the PCB electric impedance) resulting in no data monitoring through the FBG and no IoT platform connection.

Conversely, the InComEss energy harvesting system could be validated adopting a lead-based strain PEG exposed to regulatory-based vibration levels, with sufficient energy harvested for feeding the downstream circuitry and temperature data collected each minute. Figure 2 illustrates the data measurement as reported both on the IoT gateway display and on the virtual dashboard, in addition to plotting the temperature evolution measured during the test on the composite skin, with maximum value around 70 °C.



78:21:84:AD:2F:8E timings

Time	Device	Sensor	Cog	Photonics Temperature	Timediff-cog (s)	Timediff-temp (s)
2023-11-09 16:29:18....	GW-A	78:21:84:AD:2F:8E	19126	27.4	60.7	60.7
2023-11-09 16:30:19....	GW-A	78:21:84:AD:2F:8E	18516	27.1	60.7	60.7
2023-11-09 16:32:20....	GW-A	78:21:84:AD:2F:8E	17940	26.7	121	121
2023-11-09 16:33:20....	GW-A	78:21:84:AD:2F:8E	17592	26.4	60.7	60.7
2023-11-09 16:34:21....	GW-A	78:21:84:AD:2F:8E	17308	26.1	60.6	60.6
2023-11-09 16:35:49....	GW-A	78:21:84:AD:2F:8E	17065	25.9	87.5	87.5
2023-11-09 16:36:49....	GW-A	78:21:84:AD:2F:8E	17012	25.8	60.6	60.6
2023-11-09 16:37:50....	GW-A	78:21:84:AD:2F:8E	16793	25.5	60.7	60.7

Figure 2. Test parameters displayed on the InComEss IoT gateway, on the virtual dashboard and FBG-measured temperature evolution plot.

Although there is still room for improving the performance and reliability of polymeric-based energy harvesters, it has been demonstrated that the InComEss energy harvesting system solution could be suitable for adoption in aeronautics. These research outcomes support the definition of a baseline towards eco-friendly and sustainable solutions in aeronautics, whilst contributing towards a

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structured structural health monitoring with the opportunity to adopt on-demand maintenance and to reduce inspection costs by approximately 30%.

Details

Project title: INnovative polymer based COmposite systeMs for high efficient Energy Scavenging and Storage

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