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Microcontroller Aided Actuation and Wireless Control for Diagnostics and Component Placement in a Large Scaled Space Environment Chamber

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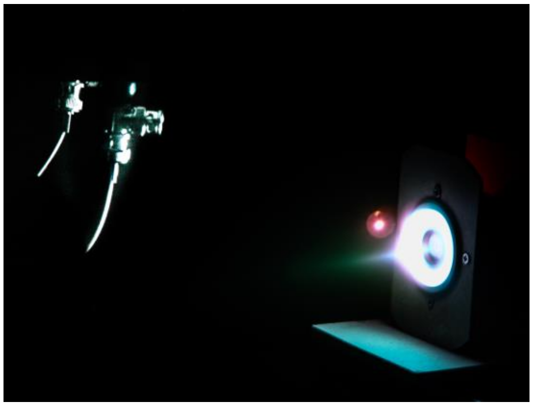
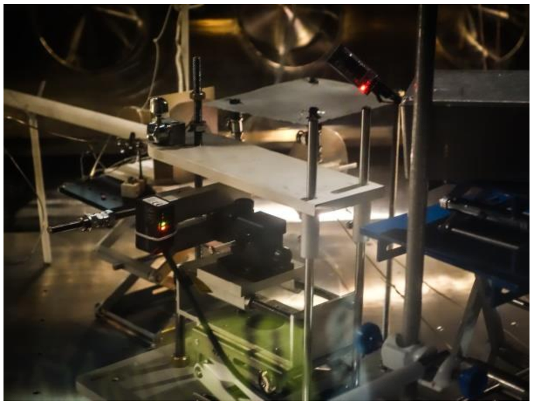
In the past decade, the use of highly programmable low-cost mini-computers and microcontrollers in scientific research and academia has leap-frogged, seeing applications in multiple disciplines including chemistry, geological sciences as well as in the Physical sciences [1,2]. Most notably, in the years since 2010, the number of technical publications which feature such microcontrollers such as the “Raspberry Pi” or “Arduino” has grown exponentially [3]. This phenomenon can be partially attributed to the relatively low cost of implementation, ease of programming, gentle learning curve, ability to customize functionality based on applications, array of mathematical and computing tools available on open source platforms, as well as small footprint on a table-top experimental setup. The advent of the boom in miniature computers and microcontrollers has also attracted much attention from academics from the space fraternity, with successful projects such as the “ARDUSAT” seeing actual deployment in space. The Plasma Sources and Applications Centre (PSAC) at the Nanyang Technological University (NTU) in Singapore have developed several Arduino microcontroller based actuation and measurement systems for



PSAC’s HET in operation with the multi-probe array in the foreground



Integrated microcontroller actuated thrust measurement and probe diagnostics suite diagnostics of miniature hall-effect thrusters (HET) in a large scaled space environment chamber. The diagnostic systems feature wireless control of automated components for remote measurements. The developed and developing systems include an in-situ automated calibration unit on a frequency modulated micro-thrust stand, an actuation stage for 3D automated spatial profile mapping of plasma plume parameters, a multiple probe array equipped with integrated data acquisition and processing, and remote controlled robotic arms for real-time maneuver of HET components for optimized coupling and thrust efficiency. The palm sized and credit card thick microcontrollers offer computing power in small payload crafts such as small satellites and cubesats where usage of space is of critical concern. In this development, the microcontrollers have also demonstrated robustness in performing numerous tasks on different systems simultaneously on a single board. The in tandem development of microcontroller based diagnostic kits at PSAC also proved to be effective tools for hands-on and inquiry/problem based learning. As PSAC is based at the heart of education in Singapore (National Institute of Education), action research in utilizing microcontrollers in the classroom as an alternative pedagogical tool has proven effective in sustaining interest in content as well as encouraging creative thinking. This is a result of the diverse applications in utilizing the microcontrollers which have potential for implementation to complement existing curricula in Physics, Computing, and even Engineering Mathematics.

[1] R. Kwok, Field Instruments: Build it yourself. *Nature* **2017**, 545 (7653), 253.

[2] S. H. Chiu, P. L. Urban, Robotics-assisted mass spectrometry assay platform enabled by open-source electronics. *Biosensors & Bioelectronics* **2015**, 64, 260-268.

[3] D. Cressey, The DIY electronics transforming research. *Nature* **2017**, 544 (7648), 125.