A Low-Cost Optical Particle Counter for Networked Deployment

W R Stanley, P H Kaye & E Hirst

Centre for Atmospheric and Instrumentation Research,
University of Hertfordshire, College Lane, Hatfield, AL10 9AB, UK

Summary

A low-cost instrument capable of counting and sizing particles in ambient air is described. Examples of results from some of many such instruments deployed at Heathrow Airport are shown and discussed.

Introduction

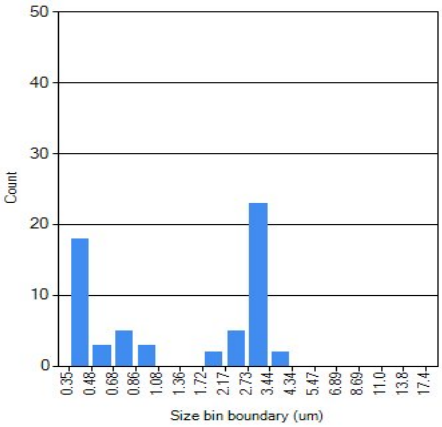
There are numerous well-established commercial optical particle monitoring instruments for measuring ambient particle concentrations and size spectra. However, these have traditionally tended to be of a unit cost that prohibits their deployment in widespread networks. In contrast, multiple low-cost instruments, while perhaps not individually providing the same levels of traceability as high quality units could, when deployed in such networks, provide unique information about aerosol dynamics and spatial behaviour that is unobtainable from a single monitoring unit. The advantages of using such sensor networks for monitoring gaseous pollutants are already evident (eg: [1, 2]). The objective of the present work is to provide a similar capability for airborne particulate monitoring by developing a low-cost Optical Particle Counter (OPC) suitable for networked deployment.

Instrument outline

The OPC is based on a custom-designed elliptical mirror and dual-photodiode detector assembly surrounding an ambient airflow. This assembly defines a small optical sensing zone within the airflow that is illuminated by the beam from a diode laser module. Importantly, this 'open-path' design does not require the spatial confinement of the airflow, meaning that particle measurement can be made on a 'natural' airflow present in wind, air-conditioning ducts, etc. No air sampling pumps and associated particulate filters (to protect the pumps) are required. If no natural airflow is present, a small low-cost electrical fan, similar to that used to cool microprocessor components, can be used. The scattered light from individual particles passing through the sensing zone is collected by the dual-photodiode, and subsequent electronics process these signals to both count and size particles at rates up to ~20,000/s. The OPC described has a build cost of approximately £140, with the potential for further cost reduction if mass produced.

Control and data storage

The OPC is controlled by an inexpensive microcontroller which, as well as managing the measurement process, also handles how the data is manipulated and stored. Particle data is compiled into histograms showing counts in a range of sizes in the region of < 0.35 to > 17 μm as shown opposite. Histograms are compiled over typically of the order of 200 ms, a variable set by the user. Histogram data can be stored locally on a memory card if the OPC is running as a standalone unit, or transmitted via USB or Serial Programming Interface (SPI) if the OPC is operated as part of networked system. The microcontroller can also manage duty cycles and put the unit into a low power state when not in use, so allowing batteries to be a viable power option.



Deployment

Up to 50 of these OPCs have been deployed in and around Heathrow Airport as part of the SNAQ-Heathrow [3] monitoring campaign funded by the Natural Environment Research Council and involving a consortium of universities led by the University of Cambridge. The OPCs are contained within a larger networked weatherproof enclosures that also accommodate detectors for several gas species and data telemetry electronics. Each of these units runs on a 12v battery for many weeks before a recharge is necessary. OPC data from this field campaign will be presented.

References

1. K. K. Khedo, R. Perseedoss, A. Mungur, 'A Wireless Sensor Network Air Pollution Monitoring System', International Journal of Wireless & Mobile Networks, 2010, 2:2, 31-45.
2. A. Lay-Ekuakille, P. Vergallo, N. I. Giannoccaro, A. Massaro, D. Caratelli, 'Prediction and validation of outcomes from air monitoring sensors and networks of sensors', Proc. Fifth International Conference on Sensing Technology, Palmerston North, New Zealand, 2011, 73-78.
3. Sensor Networks for Air Quality (SNAQ), 2010-2013, www.snaq.org