CAMBUSTION

Aerosol Instruments

An Explanation of Time Response vs Data Rate

Data Rate & Recording:

Instruments may output data either as an analogue electrical signal (which can vary continuously) or as a digital signal, which is only updated at regular intervals.

Data is usually recorded as a digital signal, so even if the instrument output is analogue, it is sampled at regular intervals and the data stored to a file. The required sampling rate is influenced by two factors:

Features of Interest:

If the parameter being recorded is expected to change slowly, there is no need to record at a high sampling rate. For example, during ambient aerosol studies, data may be recorded at 1Hz or less, since concentrations in the atmosphere do not change rapidly in the absence of a local source of particles.

When measuring directly from an aerosol source (for example an engine) changes can occur in the aerosol spectrum more quickly. For example, if an engine changes speed and load within 1 second (as happens during drive cycles), logging at 1Hz will be insufficient, as it will only record the old and new conditions, and not record the intermediate conditions. These intermediate conditions can be particularly significant for engine emissions, since it is harder to accurately calibrate and control the engine during a transient.

Therefore it is important to use a data rate appropriate to the features of interest- short-lived and rapidly changing aerosols require a high data rate.

Instrument Time Response:

However, high sampling rate alone is insufficient. The instrument used must also have a rapid time response to a step change. Instrument time response is usually quoted as $T_{10\text{-}90\%}$ or $T_{90\text{-}10\%}$. (Referring to rise and fall times respectively).

$T_{10\text{-}90\%}$ refers to the time taken for the instrument output to rise from 10% of the previous value to 90% of the new value, as illustrated in Figure 1 overleaf…

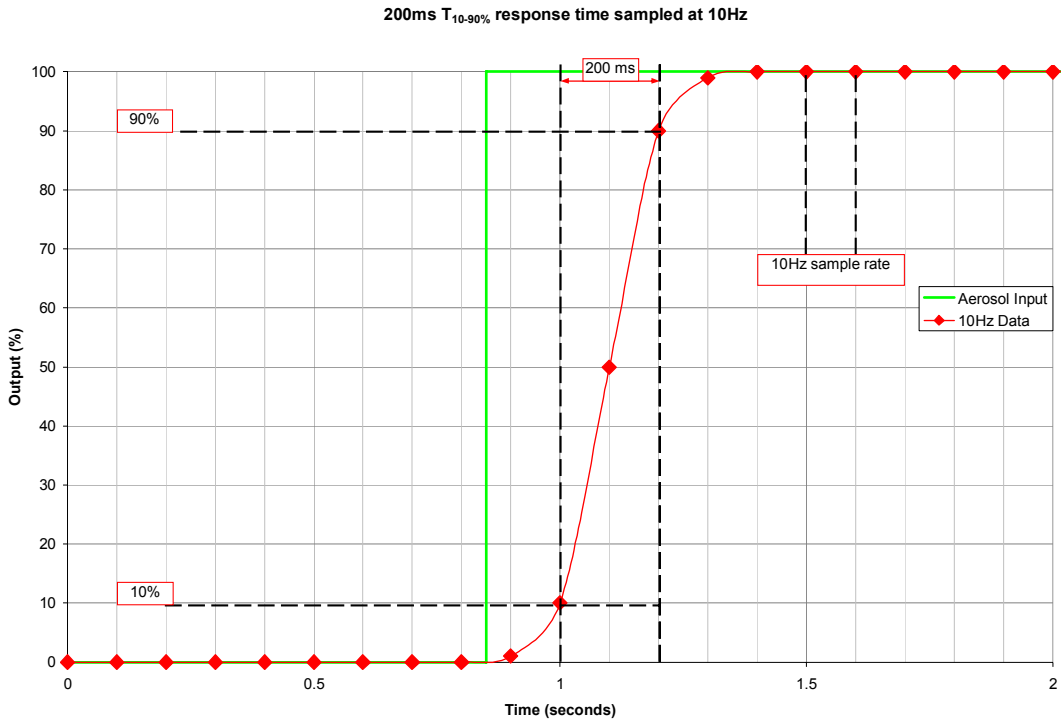

Figure 1

Figure 2 shows three different instruments responding to changes in aerosol concentration. The aerosol input goes from 0% to 100 % and returns to 0%. The importance of response time is illustrated by the failure of the 1 second $T_{90\text{-}10\%}$ instrument to correctly resolve the transient. The 200ms and 500ms $T_{90\text{-}10\%}$ instruments are able to correctly identify the transient concentration.

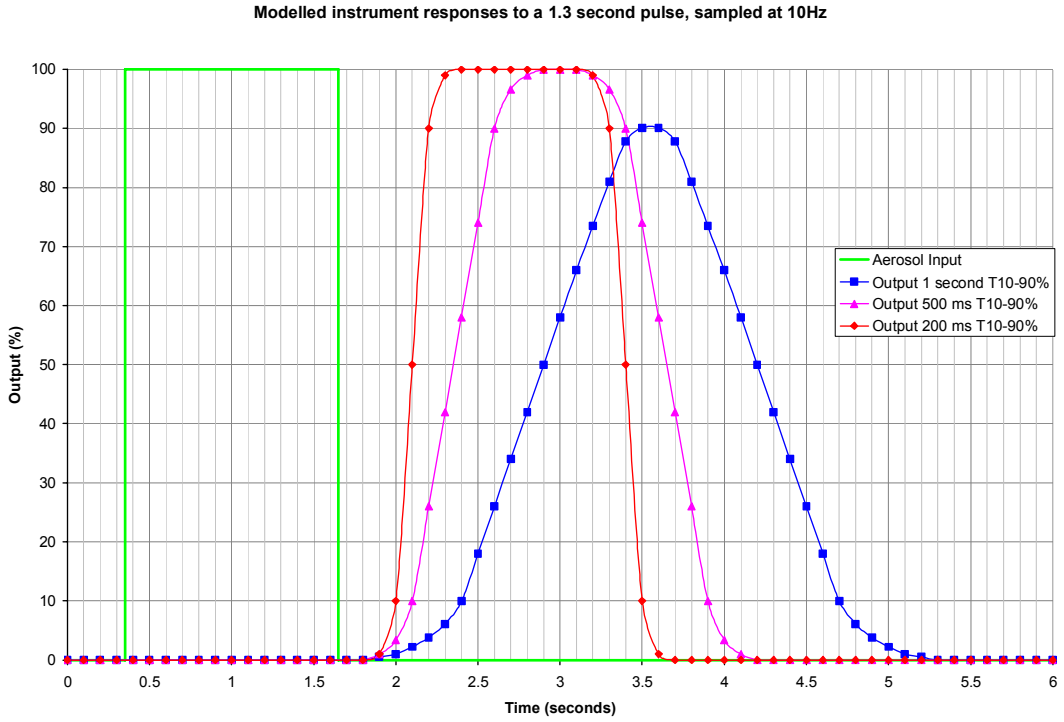

Figure 2

Note that simply increasing the *data rate* does not improve the behaviour of the instrument. The effective resolution of all these instruments would remain unchanged if the data rate were doubled to 20Hz; time response and not data rate is the limiting factor in this case.