Electrical Tailpipe PM Sensor for Diesel Engine Emission Measurements

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Introduction

- Increasing demands for diesel engines (Euro 5 etc.) will require more sophisticated emission control technologies, but also new, inspection and on-board type measurements.

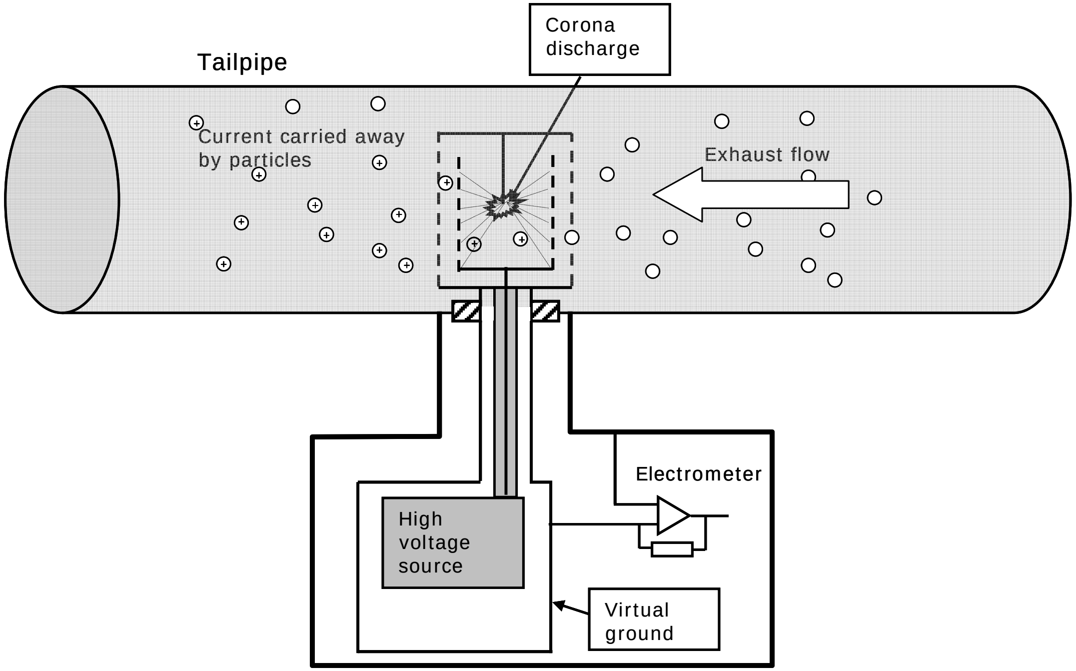
- A PM sensor is required for monitoring
  - soot emissions
  - soot trap failure

- No good technology available for on-board or inspection testing type of use
  - Limitations for the use of laboratory equipments
    - Expensive
    - Demanding to operate
    - Laborious
    - Fragile

Requirements for Particle Sensor

- Sensitive enough
- Wide dynamic range
- Simple to operate
- Reliable, repeatable
- Inexpensive
- Robust
- Should not rely on natural charge

ETaPS*) Concept



- An in-situ charger-sensor for tailpipe PM emission measurments
- Detects the amount of particles flying through the sensor (escaping charge)
- Natural charge level has no effect, only charge level change is measured
- Non-collecting device
- No sampling or dilution required (but needs sheath air)
- Option for chopped corona and AC measurement

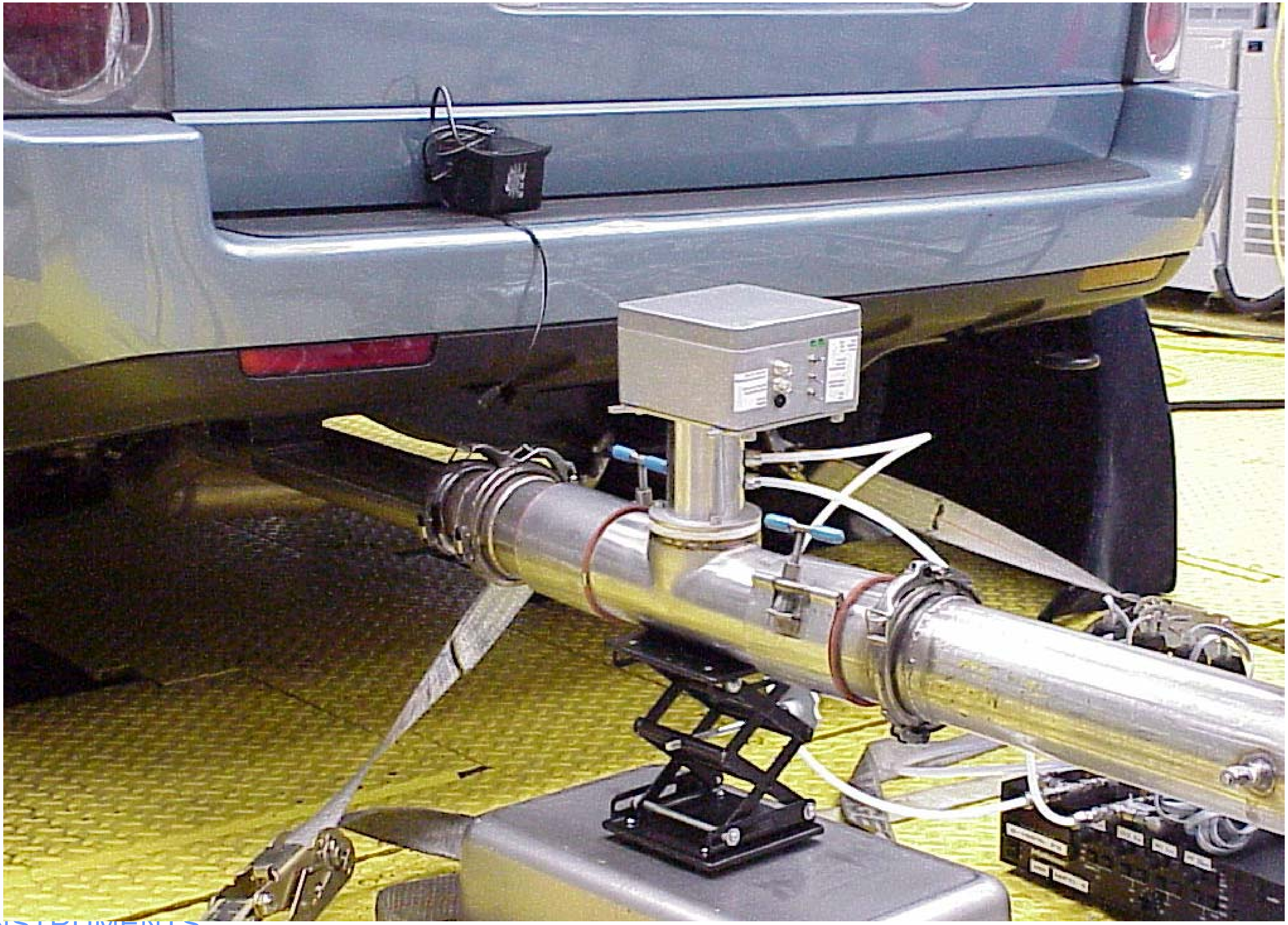
ETaPS: Electrical Tailpipe PM Sensor. Pat. Pending

ETaPS Construction

Sensor head

Electronics box and tailpipe connection

ETaPS Installation



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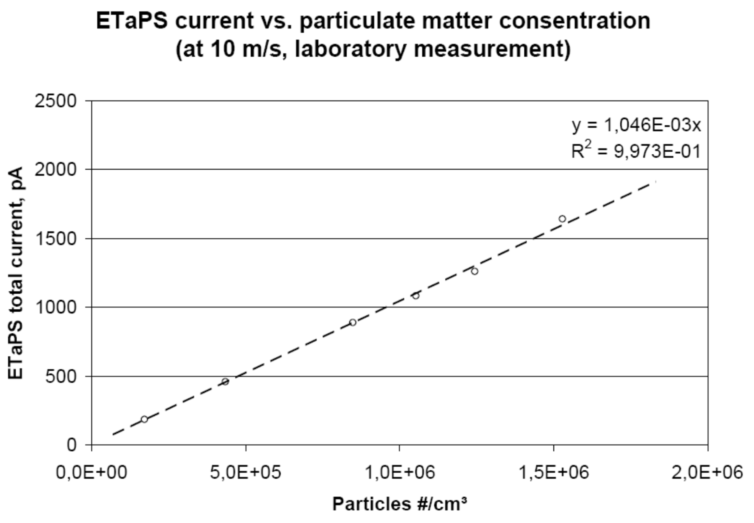
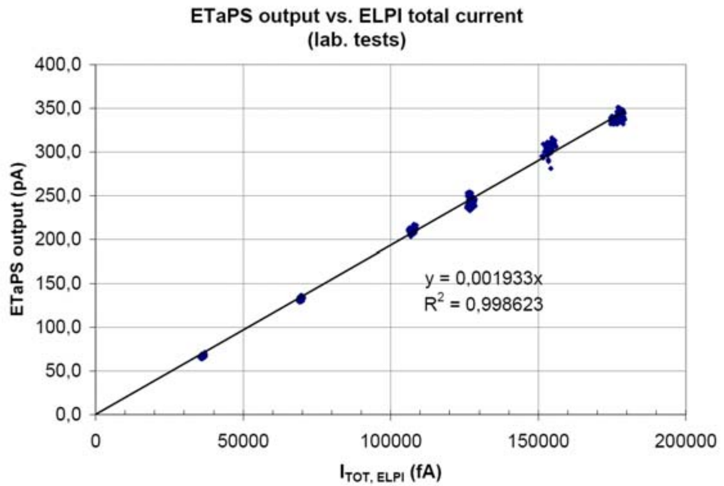
ETaPS Applications

- On-Board measurement
- In-Use testing (Inspection, testing and maintenance)
- Engine developement
- Aftertreatment developement, trap malfunction tests
- (real-world emission tests)
- (industrial hygiene)

Laboratory Tests: Linearity

- Concept first proven in laboratory tests
- Good linearity when compared to CPC or ELPI





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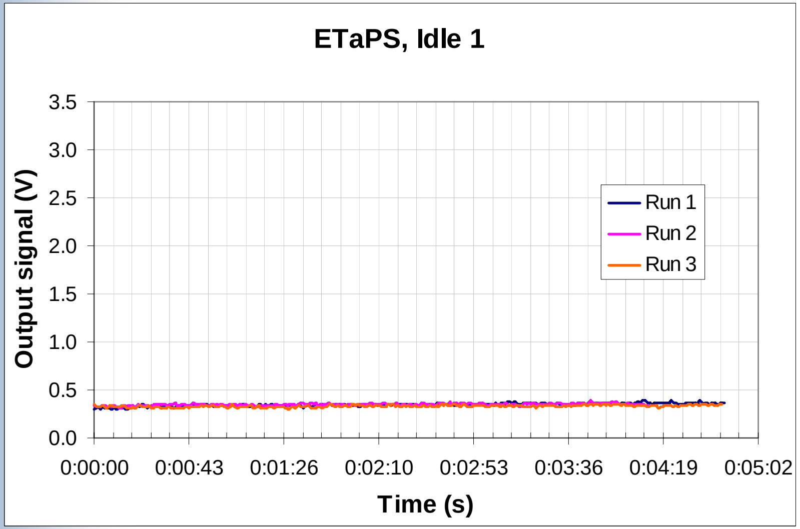
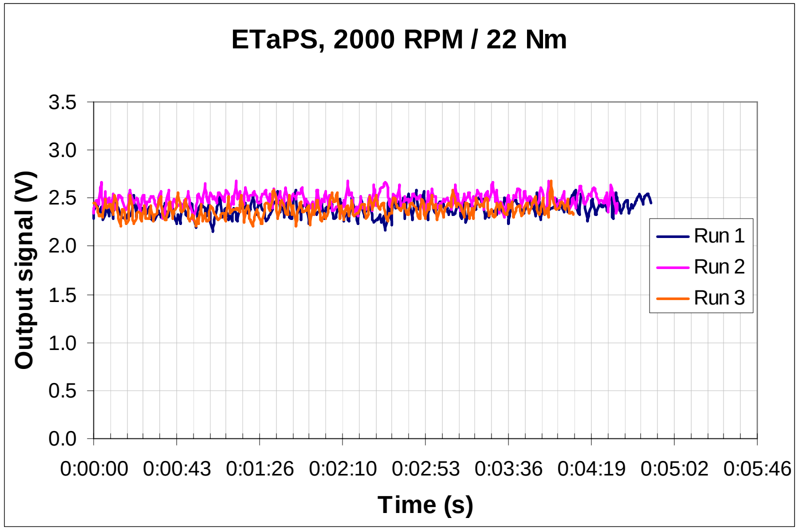
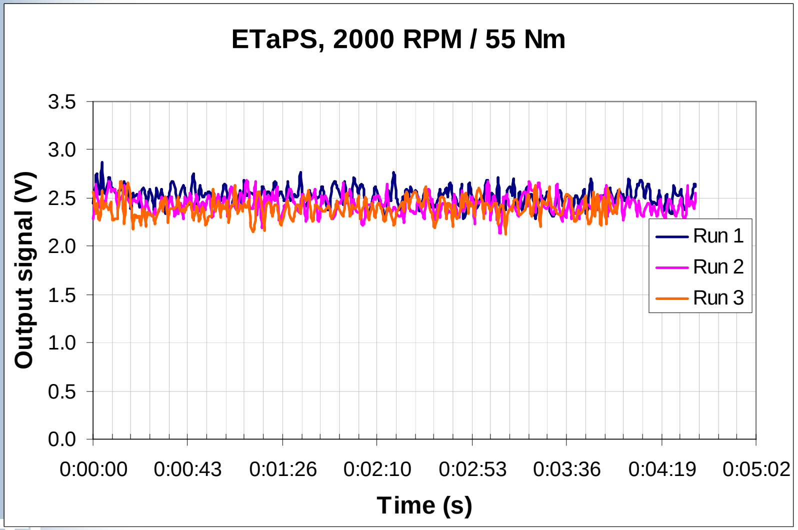
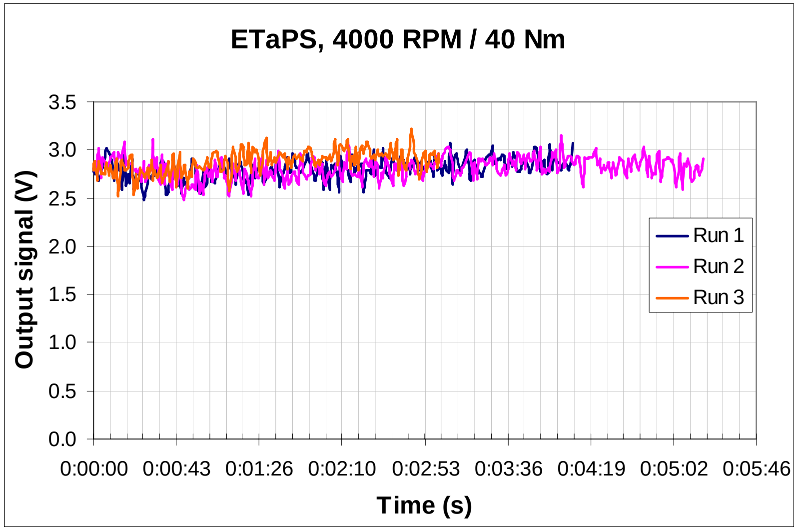
Engine Tests: Stability and Repeatability

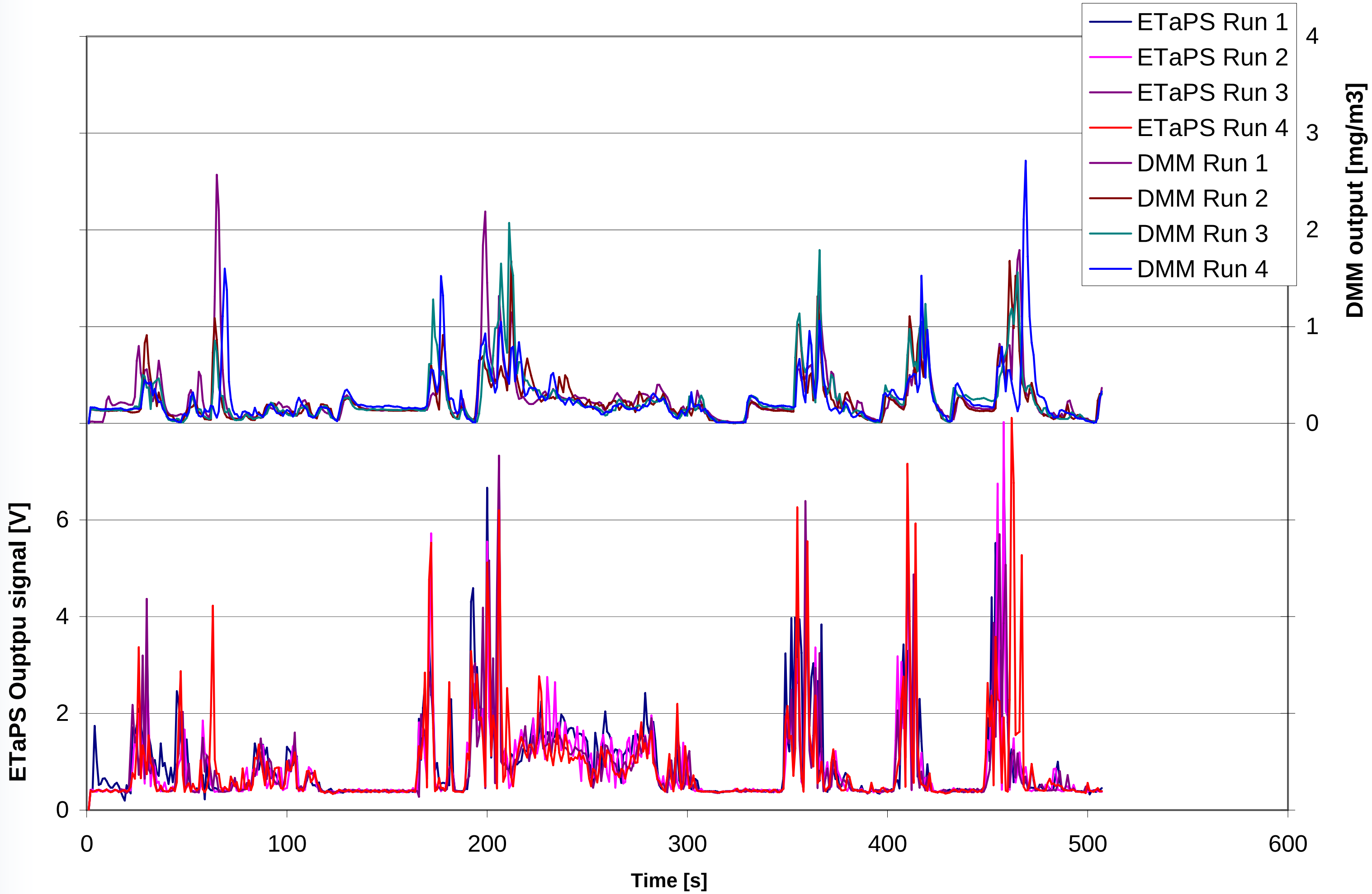








Engine Tests: Transient Measurements



1.8 TD Passenger car with oxidation catalyst

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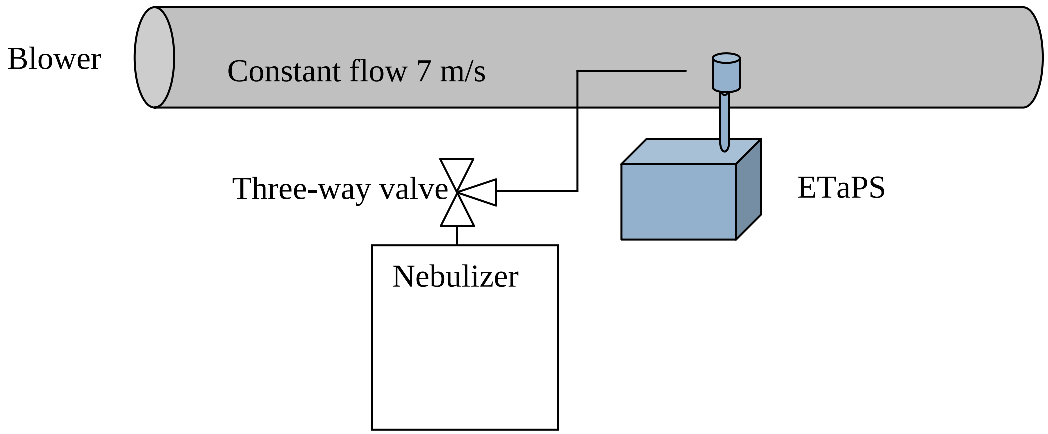
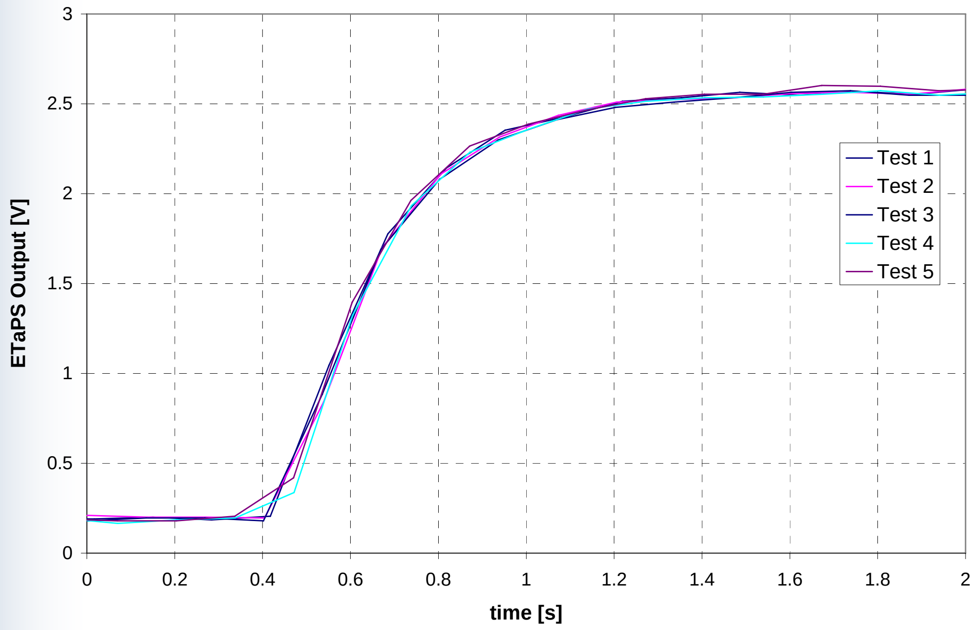
Laboratory Tests: Response Time





- Response time (t90% - t10%) 0.53 s
- Electronics time constant is the limiting factor, possibility to decrease

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ETaPS Specifications

- Tested flow rates from about 3 to 65 m/s
- Exhaust temperatures up to 530 Degrees C
- Concentrations from about 1 to 250 mg/m3
- Sheath air consumption 50 lpm, possible to decrease
- Power consumption 14-15VDC, 250 mA
- Output signal 0-10 V
  - Proportional to the total active surface area of particles
  - Affected by the exhaust flow rate

Future Work

- Study the effect of exhaust flow rate
- Study the losses
- Measure the charging efficiency for different particle sizes
- Basic research of diffusion charging in tailpipe conditions
- Correlate the ETaPS vehicle data to other PM measurements

Conclusions

- ETaPS is a new in-situ sensor for diesel and gasoline PM measurments
- Due to a lack of dilution equipment it is easily applicable for PM measurments
- Laboratory tests indicate good linearity when compared to electrical or optical instruments
- It provides stable and repeatable data of engine PM emissions
- ETaPS has fast response times due to lack of dilution. Limiting factor is electronics time constants.
- Simple construction allows low sales price and ease of installation and use

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