PLATO-PASSBY
Radar-less Passby Noise Analysis with Doppler-shift Corrected Order-Track Analysis

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Pass-by Noise Analysis with Order-Track Diagnostics

- Standard drive-by result (maximum dBA value to ISO 362) gives no clues for:
  - main **noise sources**
  - **position in test zone** associated with maximum noise

- Source identification via narrow-band order-tracking is required

- Factors influencing successful noise measurement include:
  - Track reflectively
  - Moving sources
  - **Changing frequencies** (due to vehicle acceleration and the Doppler-effect)

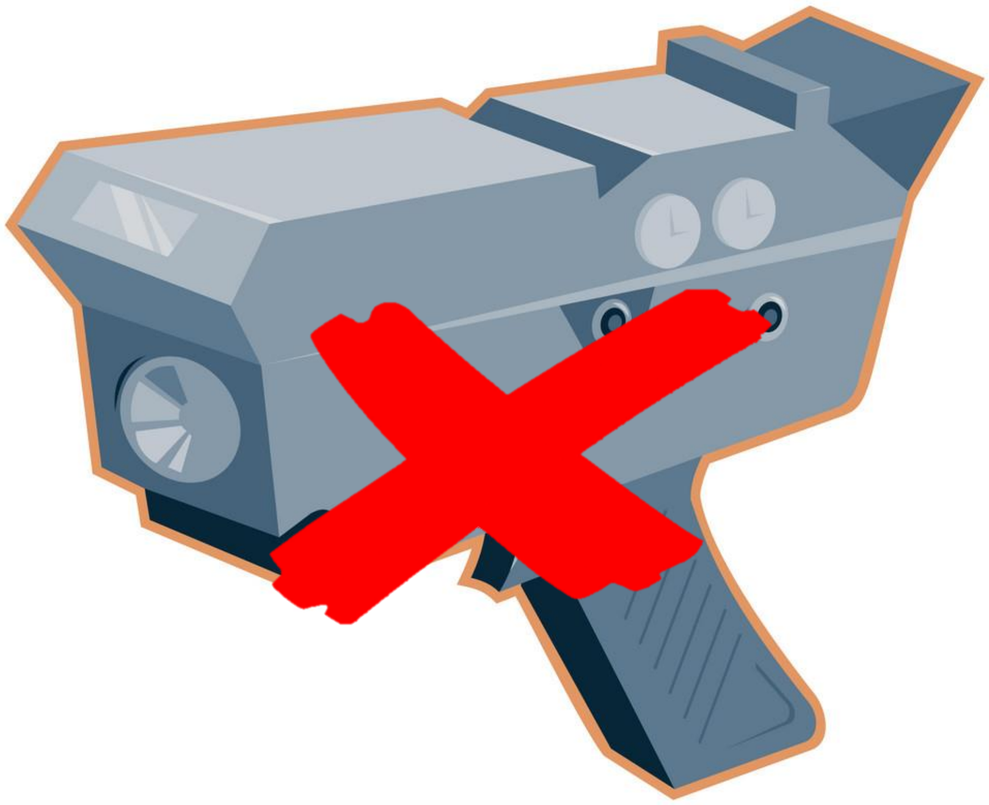
- Successful order-track (narrow-band) analysis requires **Doppler-shift correction** which requires:
  - Knowledge of **instantaneous vehicle speed** at every position throughout the test zone

Radar Not Required

- Vehicle speed traditionally measured using radar, ABD solution is radar-less

- ABD solution provides:

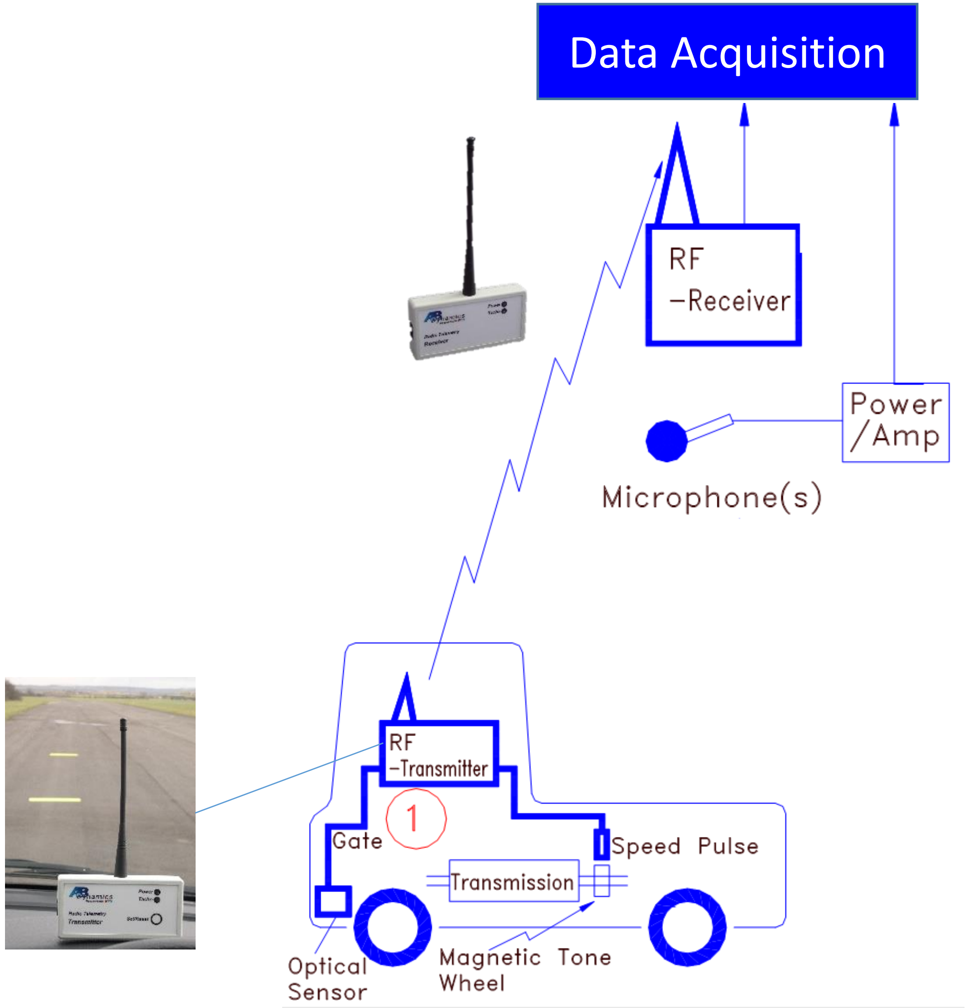
  - simple vehicle and track set-up (no radar required)
  - overall noise level (dBA) throughout test
  - Doppler-shift corrected narrow-band order analysis
  - results in standard PLATO format for engineering diagnostics



Tacho Telemetry

- **RF-transmitter** (in-vehicle):
  - relays speed pulse train ("tacho") signal to **RF-receiver** (at track-side)
  - "gated" ON/OFF by optical sensor pointing at reflective strips secured to test track at defined positions (see next slide)

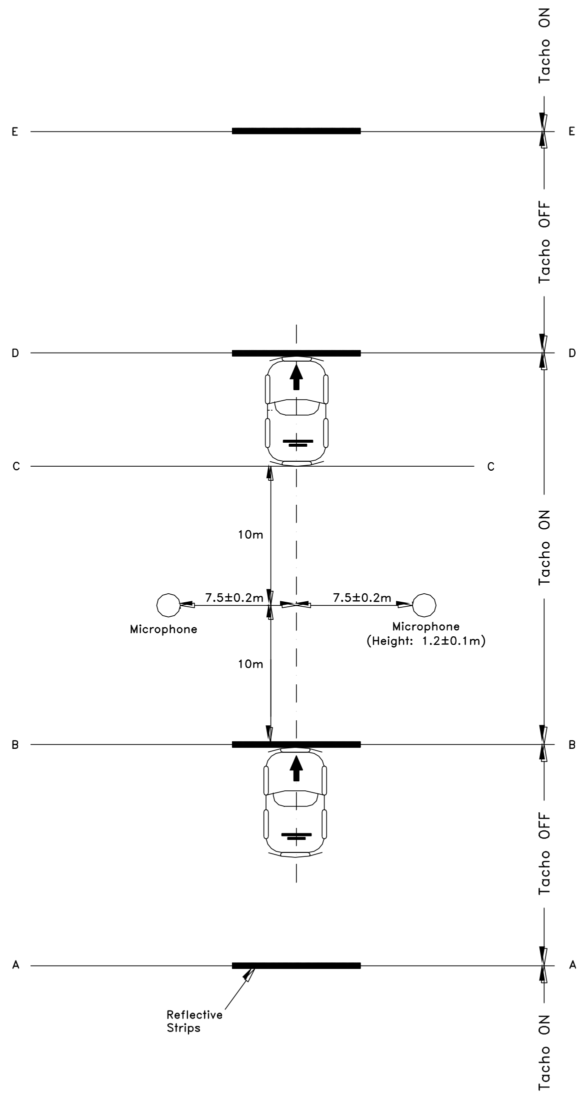
- Data acquisition system (PLATO base-station) samples:
  - tacho signal (from telemetry system)
  - microphone channels
  - typical sample rate 64KHz
    (sufficient for 20KHz bandwidth frequency analysis)



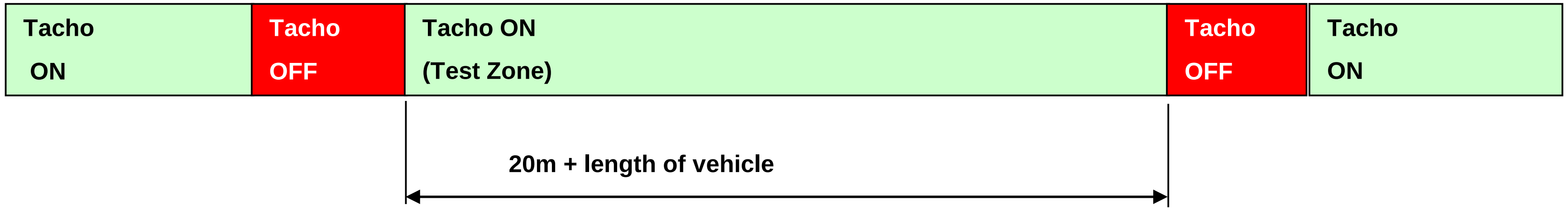
Test Track Setup

- Reflective strips:
  - Secured on track at 4-positions (A-A, B-B, D-D & E-E)
  - Tacho (speed) signal transmitted during vehicle run-up to position **A-A**
  - Reflective strip at **A-A** turns tacho signal telemetry OFF
  - Reflective strip at **B-B** turns tacho signal telemetry ON
  - Reflective strip at **D-D** turns tacho signal telemetry OFF
  - Reflective strip at **E-E** turns tacho signal telemetry ON

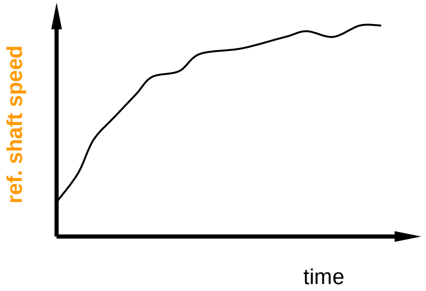
- Radar (for vehicle position):
  - NOT required

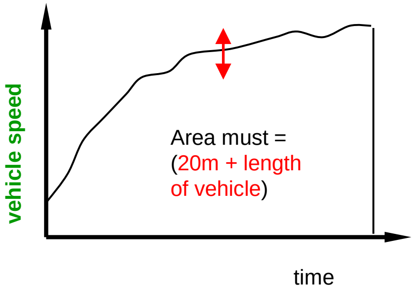


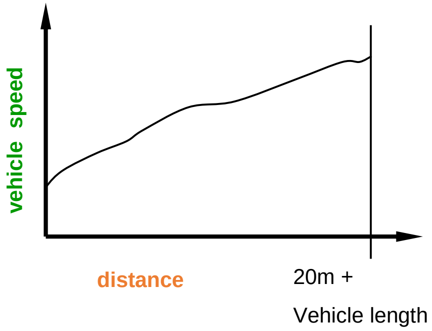
Analysis



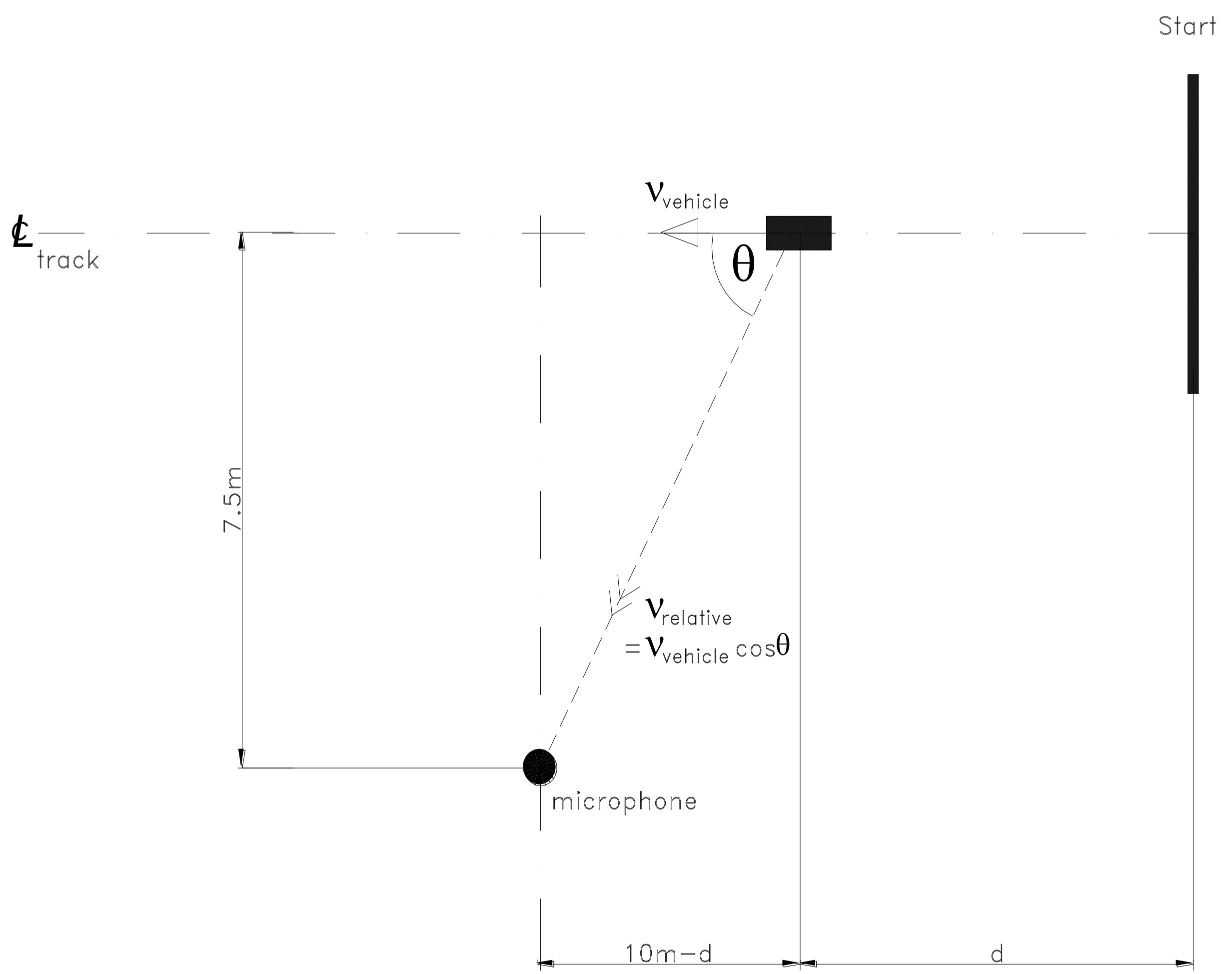
- Tacho data has two (2) gaps
- Data between gaps corresponds exactly to (20m + length of vehicle)
- Tacho data allows reference shaft speed to be plotted against time
- Constant factor relates reference shaft speed to vehicle speed
- Integral (area under) vehicle speed vs. time graph equals 20m plus length of vehicle
- X-axis of vehicle speed vs. distance graph extends to 20m plus length of vehicle
- Knowledge of vehicle speed at all positions throughout the test zone allows Doppler-shift corrections to be made







Test Track Geometry



Order Analysis

a) Use the pulse/revolution value of the tacho record to evaluate the time frame corresponding to N revolutions

b) Generate a digital anti-alias filter whose corner frequency is appropriate for the average shaft speed in that time frame

c) Digitally anti-alias filter the 64kHz noise records for that time frame

d) Use **individual tooth timings** to re-sample the 64kHz noise records for that time zone to create shaft speed synchronized samples eg 1024 points over 4 revolutions

e) If Doppler-shift correction is selected, the re-sampling rate is adjusted according to the following equation using vehicle velocity and position information at each re-sample point

$$\text{Measured Frequency (Hz)} = \left[1 + \frac{V_{vehicle} \cos\theta}{C}\right] * \text{True Frequency}$$

where:

C= speed of sound (m/s)

$V_{vehicle}$, and θ *as defined in previous slide*

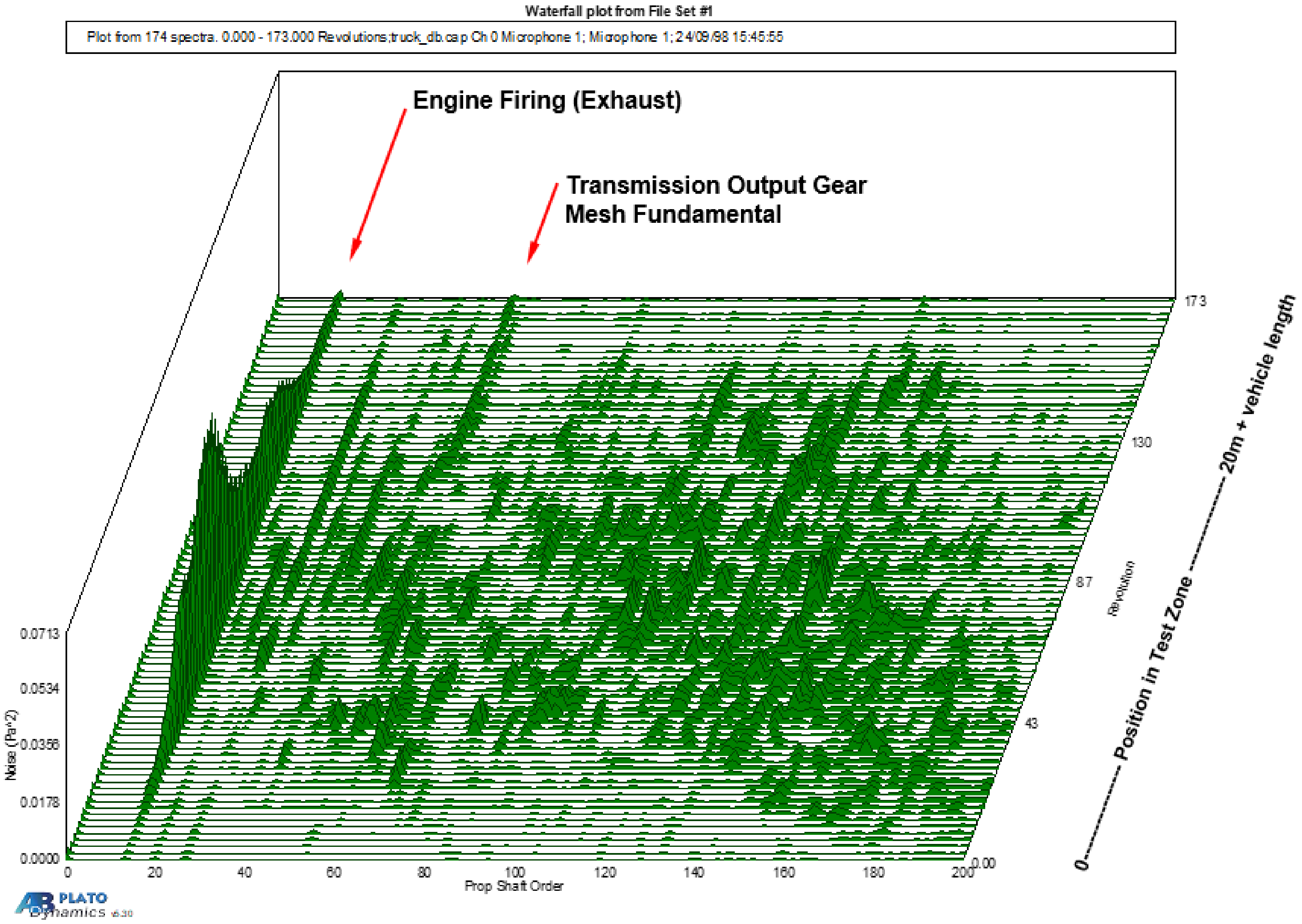
f) Calculate the FFT (order spectrum)

g) Repeat (a) to (f) for the next N revolutions in the test zone until the data is exhausted

Example ("3D") Data

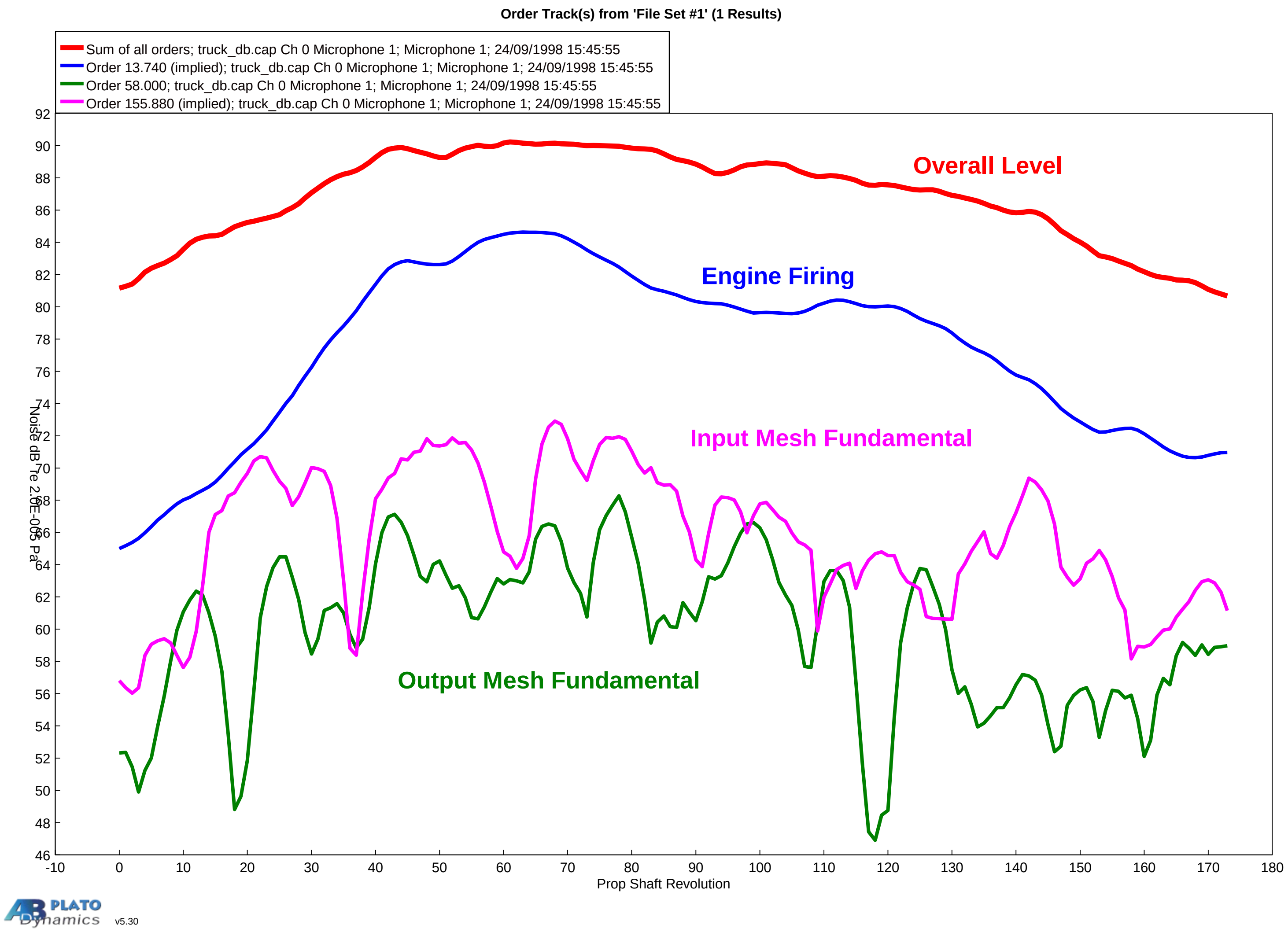
Clear indication of noise order-tracks

"Straight" order-tracks indicate that Doppler-shifted frequencies are properly corrected.



Example Overall Level & Order-Tracks

Source-specific noise order-tracks extracted using regular PLATO NVH system software



Summary

- calculates vehicle position and speed from a contiguous tacho pulse record
- no requirement for radar system on track
- cost-effective and easy to set-up
- provides legislation-driven (overall level) and development engineering results
- provides the engineering data at high levels of resolution throughout the test zone, with extremely accurate Doppler-shift correction.

Useful Links

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