Tom's Tuning Tools

GSF Dyno - The Dynamometer Software for Well-Founded Tuning

GSF Dynamometer software in combination with a commercial sound-recorder allows for making power/torque curves of a motorcycle (or car). Dyno runs are done (recorded) on the street and analysed on the PC at home. Dyno runs are essential for tuning and correct jetting of the carb. Here you found the minimum-cost dynamometer. All you need is to download the dyno software, a sound recording system and I suggest to build the voltage divider as described below.

DE: http://kodija.de/tom/GDSetupD.exe

EN: http://kodija.de/tom/GDSetupE.exe

FR: http://kodija.de/tom/GDSetupF.exe

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Introduction

The idea for the GSF Dyno software was to measure the power curve of a motorbike just by recording the sound of the engine with a commercial sound recording system like Mini-Disc or MP3 recorder. The engine rotation and its time derivative (acceleration) should be calculated from the recorded sound. Knowing in addition the total mass (vehicle, driver, gas...), the Cd value (drag coefficient) and the gearing ratio would then be enough to calculate the power output with respect to engine rotation.

However, recording the sound or noise of the engine is not very easy. Usually, a lot of other noise will also be recorded making the analysis difficult. Furthermore, usually microphones are unable to record sound-frequencies of less than 50Hz (3000RPM on a two-stroke single cylinder) and in addition the records are often overdriven.

The GSF Dyno software still can handle recordings done with microphone, however the success is not sure. An eraser tool was implemented to allow the user to erase noise from the record. Much better results can be obtained using a voltage divider. With it the alternator (and its changing frequency) can be recorded and replace the sound signal. The AC voltage produced on motorbikes is directly proportional to the engine revolution.

This dyno software work very well on different Vespas, Lambrettas and for sure also on other vehicles. Recently I tried it with a microphone in the passenger cab of my car - it worked :-) Here is the output of carburetor jetting session of my tuned 177ccm Pinasco Vespa:
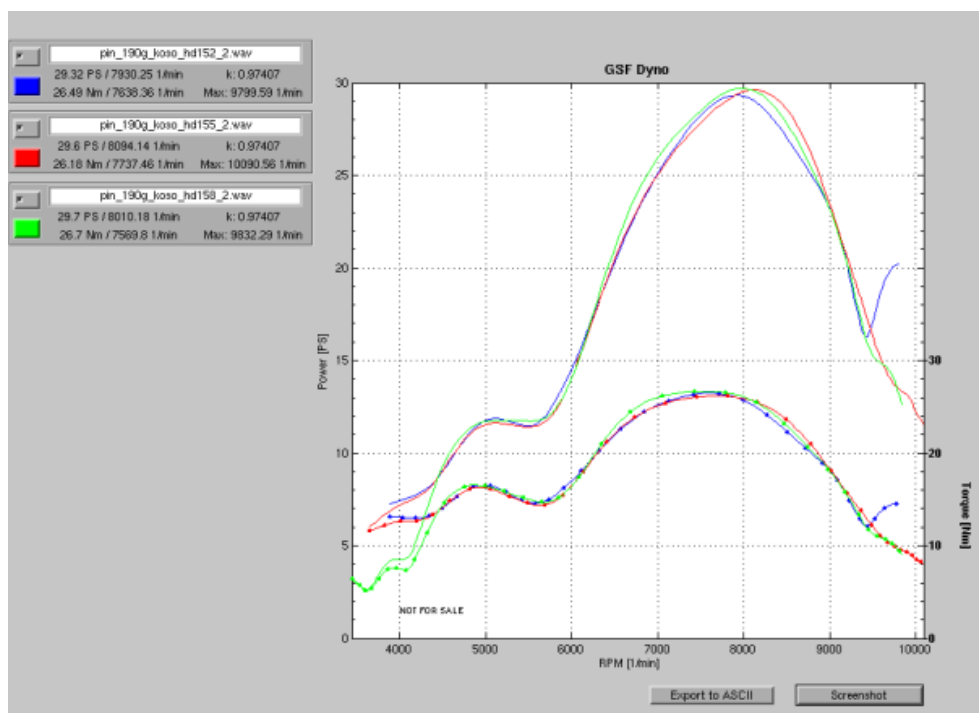
The dynamometer software was extended to be able to use also the signal of a digital speedometer like used for bicycles. Even combinations of those two are possible (e.g. Left Channel: DIGI, Right Channel: ALT). This allows to record the data with varying gear ratios e.g. during a race or on a variomatic scooter. Furthermore, the dyno software accepts signals from a rotating inertia drum and its combination with the alternator. It is used on at least three chassis dynamometers, here is the one:

The software allows for different types of signals but for all of them you need a recording device (Mini-Disc, MP3 recorder, DAT, PC etc.). The software accepts only uncompressed WAV files (PCM WAV), so if your recording device does not support WAV files you need to convert them with your PC. A nice program for manipulating audio is Audacity.

How to Connect the Recorder

Measurement with microphone

The measurement with microphone is not as accurate as using a voltage divider. However, who wants to try it anyway should consider the following. If possible, an undisturbed recording should be done. I.e. in the car: close the windows and

turn off the music. As possible do not talk ;-). On a motorcycle it becomes still more difficult - place the microphone into a linen cloth and on a wind protected place (perhaps even in the air-box). Read the 'Edit WAV File by Hand' Window and Example: Recording with Microphone section to learn how to process the recording.
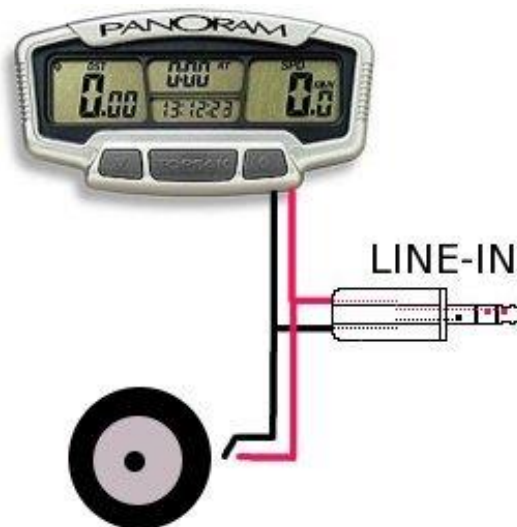
Recording the Dynamo/Alternator Signal

Let's assume you would like to use the software in its street dyno version. Here you will get the best results, if you connect the recorder to the electric generator. For that you need the voltage divider to divide the voltage from the alternator (Usually 12V) to 0.5V which can be connected to the LINE-IN plug of the recorder. If your recording device only has an MIC-IN plug you have to change the voltage divider to the specifications of your MIC-IN, one possibility is shown below to the right.

R1: 10 kOhm
R2: 470 Ohm
D1,D2: N4001

R1, R3: 10 kOhm
R2: 470 Ohm
R4: 33 Ohm
D1, D2: N4001
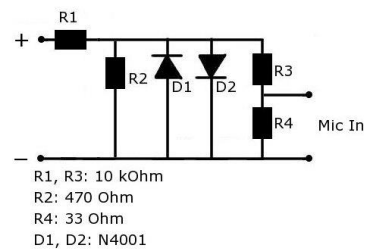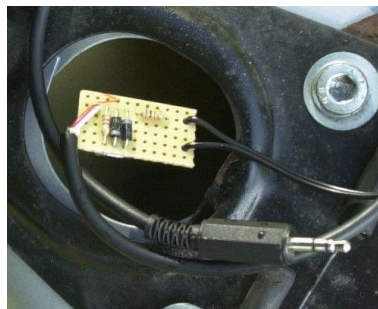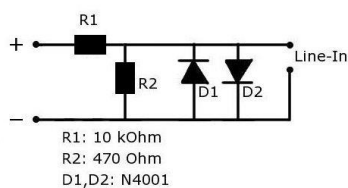
Connect the ground to the chassis and the positive pole to the light or similar.

Recording the Digital Speedometer Signal

Mostly not as accurate as the generator signal is the digital speedometer signal. This is due to the single magnet mounted to the wheel - producing one signal per wheel rotation. Increasing the number of magnets would increase the accuracy. In my case connecting the digital speedometer was very easy. I cut the wire which is going from the speedometer to the wheel sensor and connected it parallel to the LINE-IN.

Recording the Digital Speedometer Signal and the Dynamo Signal Simultaneously

Also easy, just combine the two. E.g., dynamo on the left channel and speedometer on the right channel. If your speedometer has its own battery the ground connection is not really correct, however there are good chance that it is functioning any way.

R1: 10 kOhm
R2: 470 Ohm
D1,D2: N4001
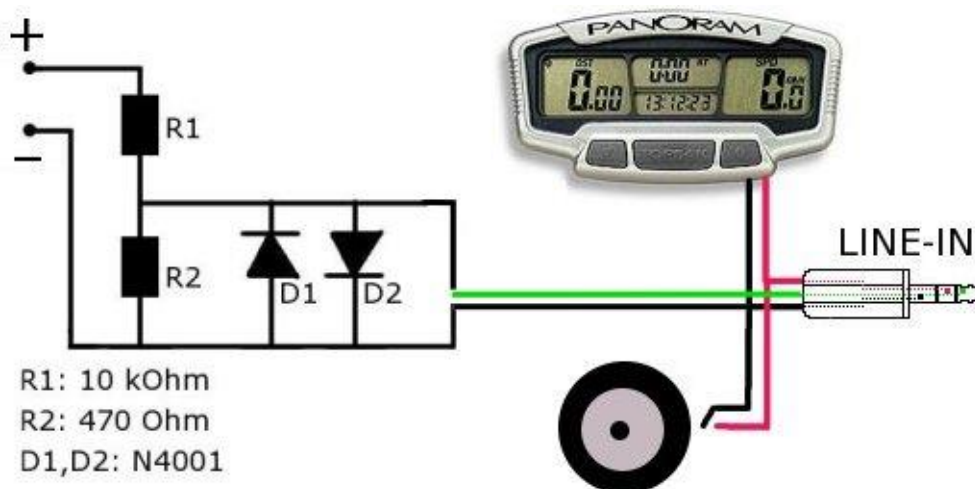
Measuring your own Power Curve

Now if you have managed to record a signal you can start doing the runs. What you need is some 100m of a flat street somewhere where no one will be disturbed or endangered by you running the street several times up and down with full throttle. I always try to make measurements on the same place and with similar wind conditions. Warm up the engine (very important). Connect your recorder to the vehicle and start it. On my 4 gear Vespa I change into third gear while slowly driving with low RPM. Then, I suddenly open the throttle and wait until I reach the maximal RPM. Some people prefer to open the throttle gradually

to see the carburettor setting over the whole throttle range. How you like... After reaching the maximal RPM you can stop the recorder and move on to your PC to analyse the recording.

The GSF Dyno Software

Installation

Download the TTT Bundle and execute the setup file:

DE: http://kodija.de/tom/GDSetupD.exe

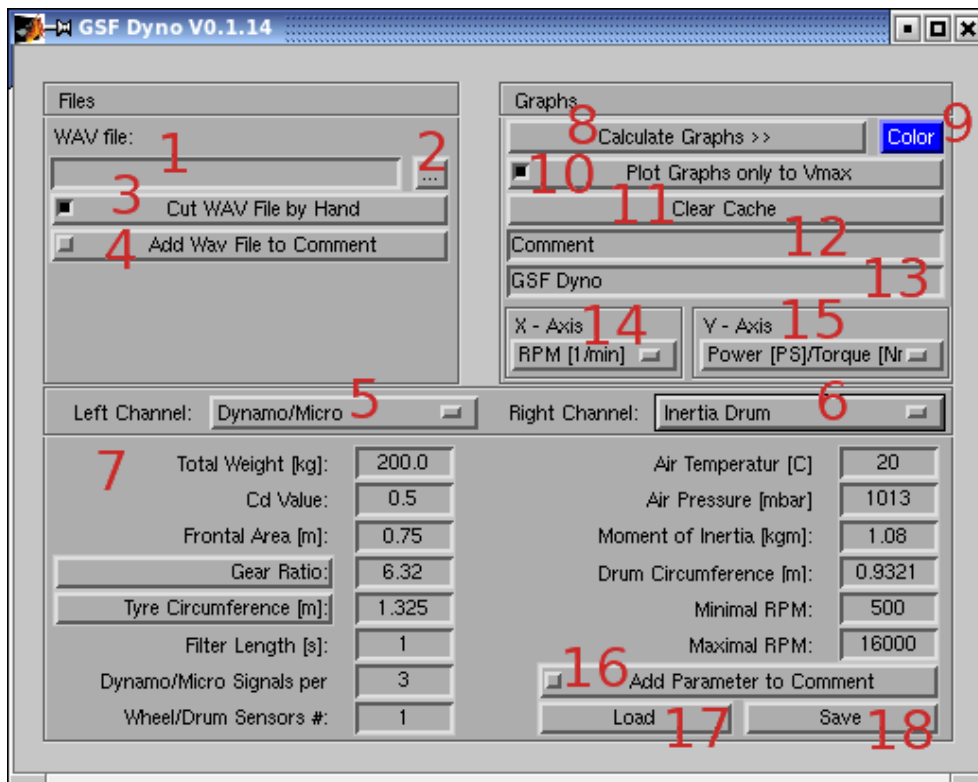EN: http://kodija.de/tom/GDSetupE.exe

FR: http://kodija.de/tom/GDSetupF.exe
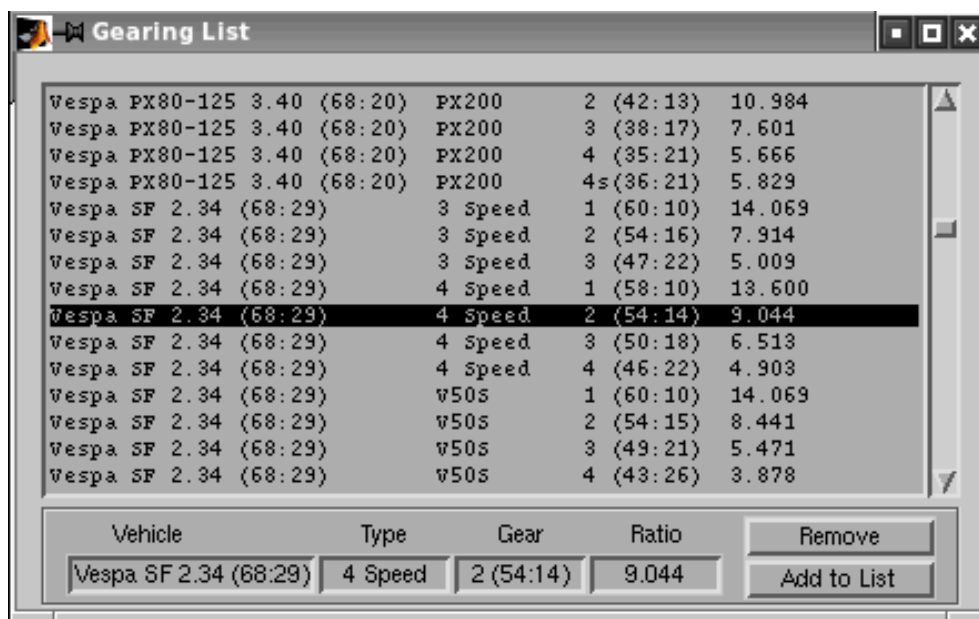
The Main Window

The main window is composed of several buttons which allow the user to set all the parameters needed by GSF Dyno software to calculate the correct curve.

Let's describe the buttons according to their numbers in the figure above.

1. Type in the name of the wav-file you recorded during the run, or

2. Browse your directories to find and set the wav-file name.

3. If this checkbox is activated then another pop-up will be displayed during the calculations where you can select the range of the file which should be used for the analysis (see next section).

4. Activate this button to add the wav-file name to the comment.

5. Select the type of signal for the left channel (Dynamo / Wheel Sensors / Inertia Drum / Ignition / Off).

6. Same for the right channel (Dynamo / Wheel Sensors / Inertia Drum / Ignition / Off).

7. Here all the physical parameters needed for the calculation are asked:

- *Total Weight [kg]*: Thats the weight of the vehicle plus everything what was loaded on (driver, petrol...)
- *Cd Value*: Drag coefficient for your vehicle. Most of us has to guess that. Somewhere between 0.3 and 1.
- *Frontal Area*: The frontal area is needed together with the Cd value to calculate the drag.
- *Gear ratio*: The ratio between the wheel and the engine. If the engine makes 6 revolutions while the wheel makes only 1 than the ratio is 6. Pressing this button shows a list with many Vespa gearing ratios.

A mouse click onto an item of the list activate the item and its gearing ratio is transfered to the main program window. Use the "Remove" button to remove an item from the list or the "Add to list" button to add the gearing ratio typed in to the text fields to the left of the "Add to list" button.

- *Wheel Circumference*: Circumference of the tire. Pressing this button open a Tyre Circumference Calculator.
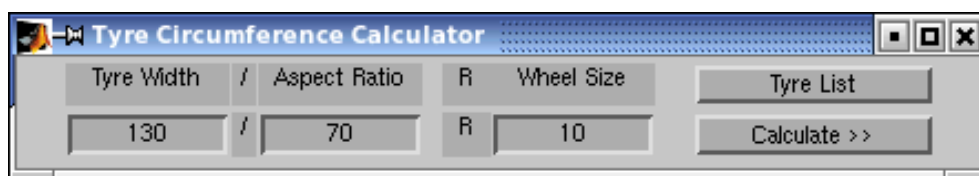
Type in the specification of your tyre to calculate its circumference. Pushing the 'Calculate' button calculates the circumference and transfers it to the field on the main panel. However, the tyres often differ from the theoretical circumference value, therefore a list of measured circumferences can be

reached by pushing the "Tyre List" button. This list is similar to the 'Gearing Ratio List'.

- *Filter length [s]*: That smooth the output curve. Higher values make smoother curves. Smoothing is needed due to the finite (and coarse) resolution of the numerical calculation. Choose a value which produce similar curves you are used to see from a commercial dyno.
- *Dynamo/Mic Signals per Rotation*: If you recorded the dynamo/alternator (or microphone), type in its amount waves per motor rotation. If you don't know it try some numbers until you get the right RPM range. For the microphone recordings: 2Stroke 1Cylinder: 1, 2Stroke 4Cylinder: 4, 4Stroke 4Cylinders: 2.
- *Drum Sensors / Wheel Sensors*: This button switches between the amount of Drum Sensors and Wheel Sensors, depending on the signal you use. If you use a digital speedometer signal, then this will be 1 due to one magnet on the wheel - increasing this value (i.e. increasing the amount of magnets on the wheel) will result in more accurate results.
- *Air Temperature*: Small changes in power output can occur according to air temperature changes. To take that into account type in the air temperature during the run. [DIN 70020]
- *Air Pressure*: Same background as for Air Temperature.
- *Momentum of Inertia*: Used for inertia drums.
- *Drum Circumference*: Used for inertia drums.
- *Minimum RPM*: Minimum RPM to use in calculation.
- *Maximum RPM*: Maximum RPM to use in calculation.

8. Press here when everything is set right to calculate the curve.

9. Press to change the colour of the curve to be plotted. However, it can also be changed afterwards in the output graph.
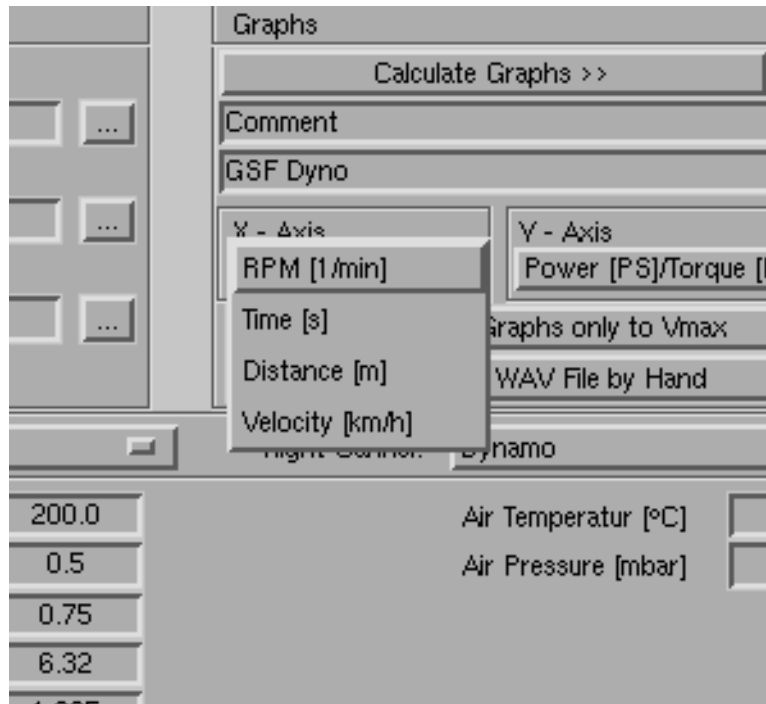
10. If this checkbox is activated the curve will be cut after the maximal velocity was reached.

11. Pushing this button clears the internal memory of the software.
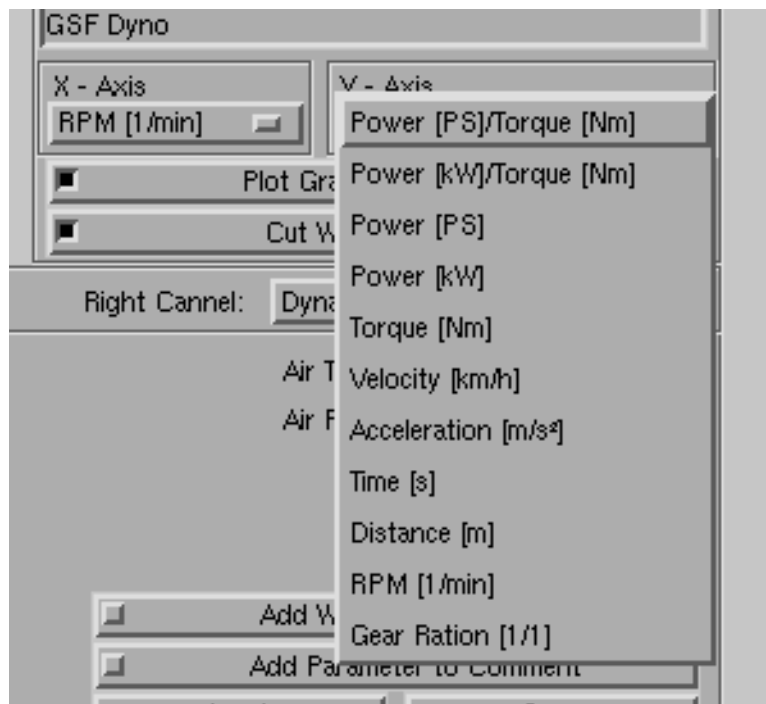
12. Write some comments to the curve here.

13. The title of the output graph.

14. Choose what the software should display on the X-Axis

15. Choose what the software should display on the Y-Axis. Note that power is in kW or continental Horse Power (PS,CV not HP).


16. Activate it to add the physical parameters to the comment.

17. Load the parameters from file.

18. Save parameters to file. If you save them in the file named *gsf_dyno_start.cfg* they will be automatically loaded when you start GSF Dyno the next time.

The Edit WAV File by Hand Window

If the checkbox 3 was activated when you pressed the Calculate button, then an additional pop-up named *Edit WAV File by Hand* will be displayed after some calculation time.
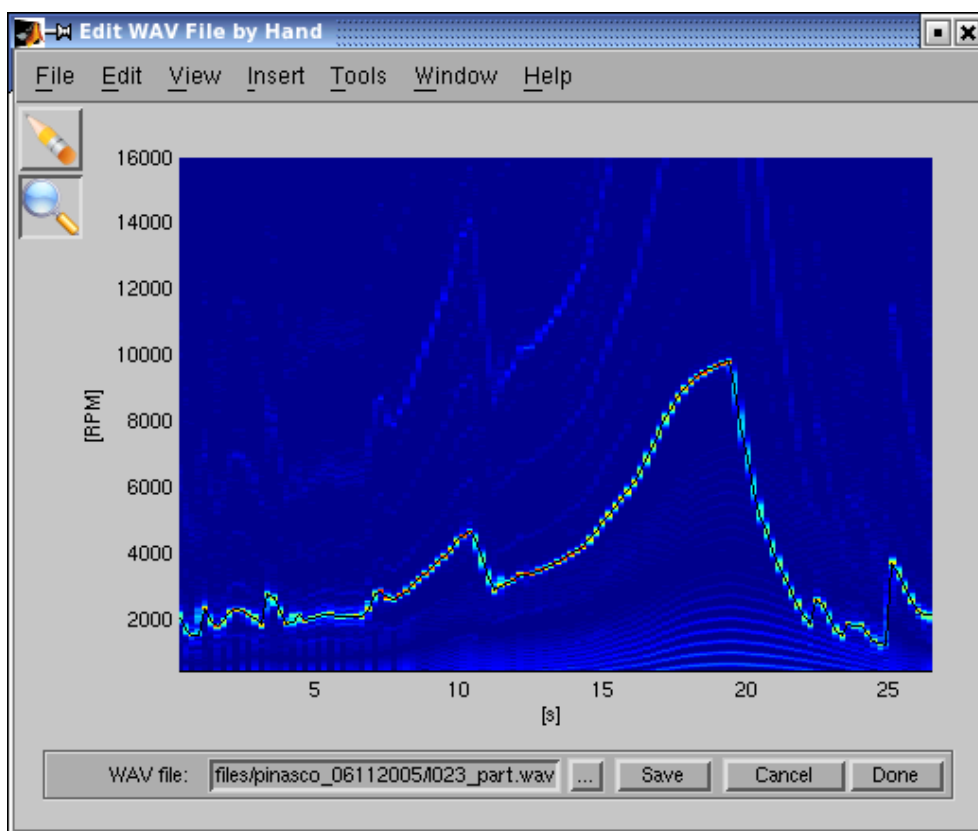

What you see is an spectrogram. On the x-axis the time is displayed while on the x-axis the frequency (here in RPM) is shown. The signal is represented by warm colours (red and yellow) while cold colours mean no signal. The black line should connect the signal without big jumps accept when the gear was changed. The frequency (RPM) is proportional to the velocity of the vehicle: High frequency means high velocity. The spectrogram is also a nice indicator if your recording was good. If you do not see a continuous line in red or yellow over blue background your signal to noise ratio is too small. If the black line is jumping between two yellow lines, then you probably over-amplified the recording. In this case you can try to narrow the RPM range by the max and min RPM

parameters in the main window and/or use the erasure function to erase disturbing yellow lines.

The figure above shows a typical street record: At the beginning the motor is idle (approx. 2000RPM; 0-7Sec), slow riding was started to get into the second gear (7-11s). Then the throttle was hold opened until the maximal RPM was reached (here approx. 10000RPM; 7-19s). After that the third gear was used to slow down the engine (20-26s).

We are only interested in the second gear part, so click and pull a rectangular section around the region of interest (12-21Sec).
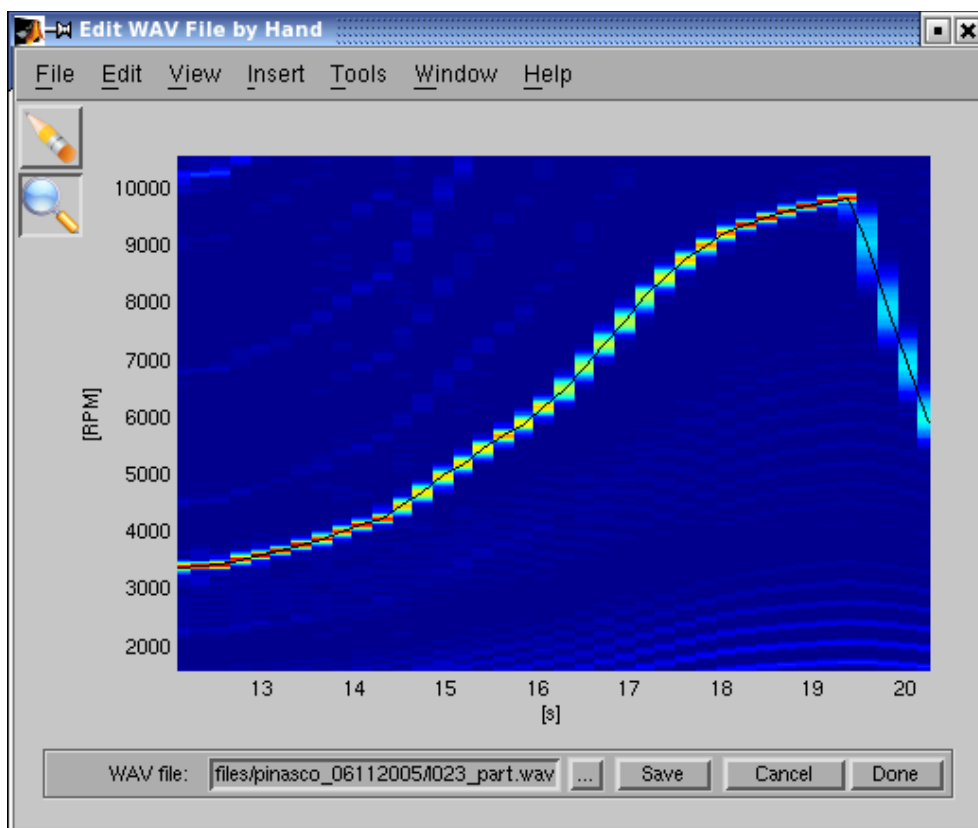

That zooms into the rectangular. To zoom out again click the right mouse button. Save the file or choose a different file name and save it than. Go on by pressing Done. The calculations will be finalised and you should get the output figure with the graph.

**Example: Recording with Microphone**

Here is an example of a microphone recording. As previously mentioned, the quality of the recording can best be seen on the basis of spectrograms.
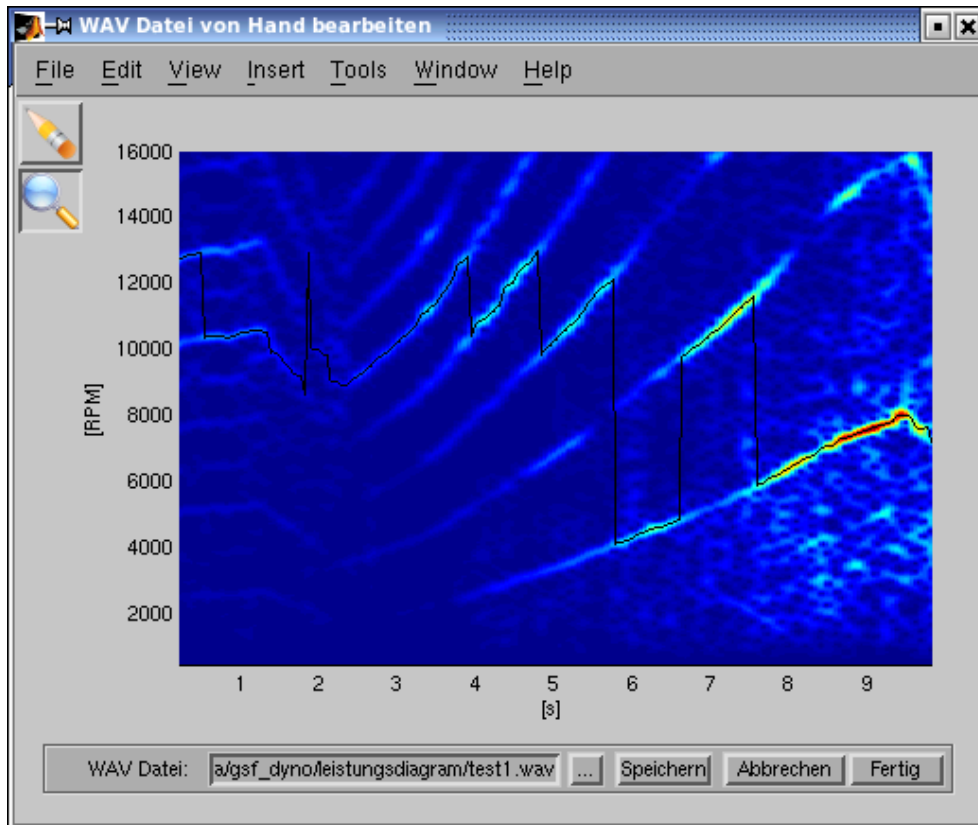
Nice to see how the black line jumps between different red/yellow lines which would destroy the correct calculation. But here we have luck, by setting the Maximal RPM parameter in the main panel to 8500RPM, we can exclude signals above 8500RPM from the computation:
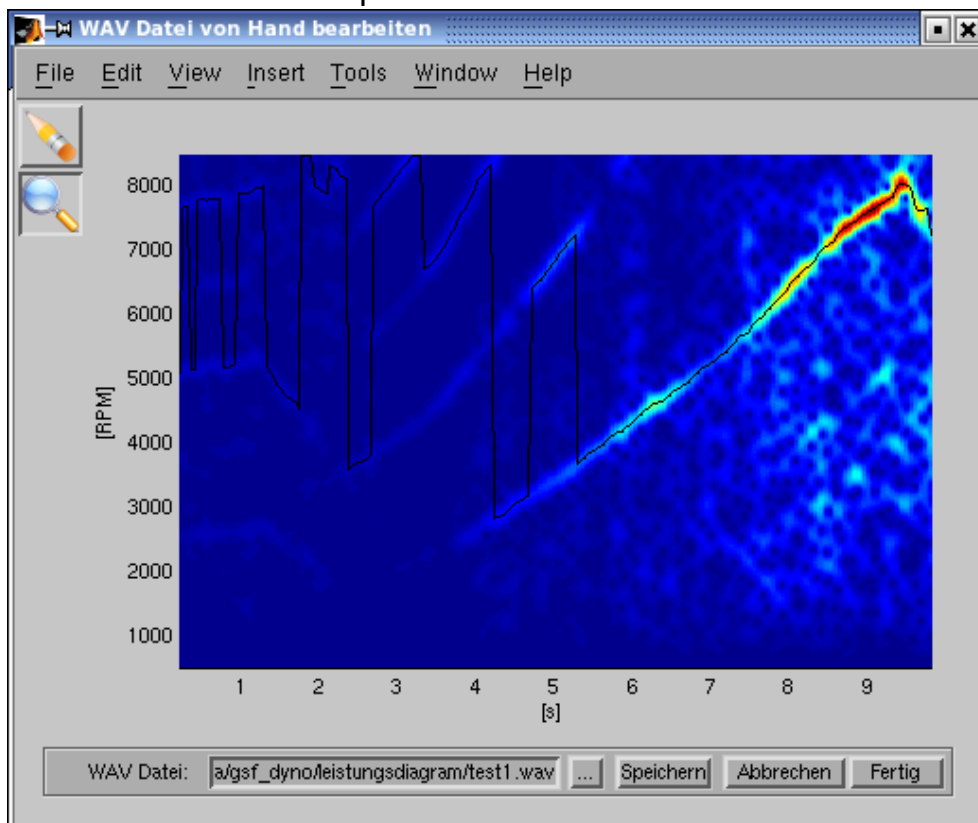
Now change from the zoom function to the eraser function by pressing the eraser button. Erase the region where the black line is on the wrong red/yellow line. The black line will be redrawn. Erase as long that the black line is continuously on the right red/yellow line. If you have to restrict the time window again, you can change to the zoom function by pressing on the magnifier button.
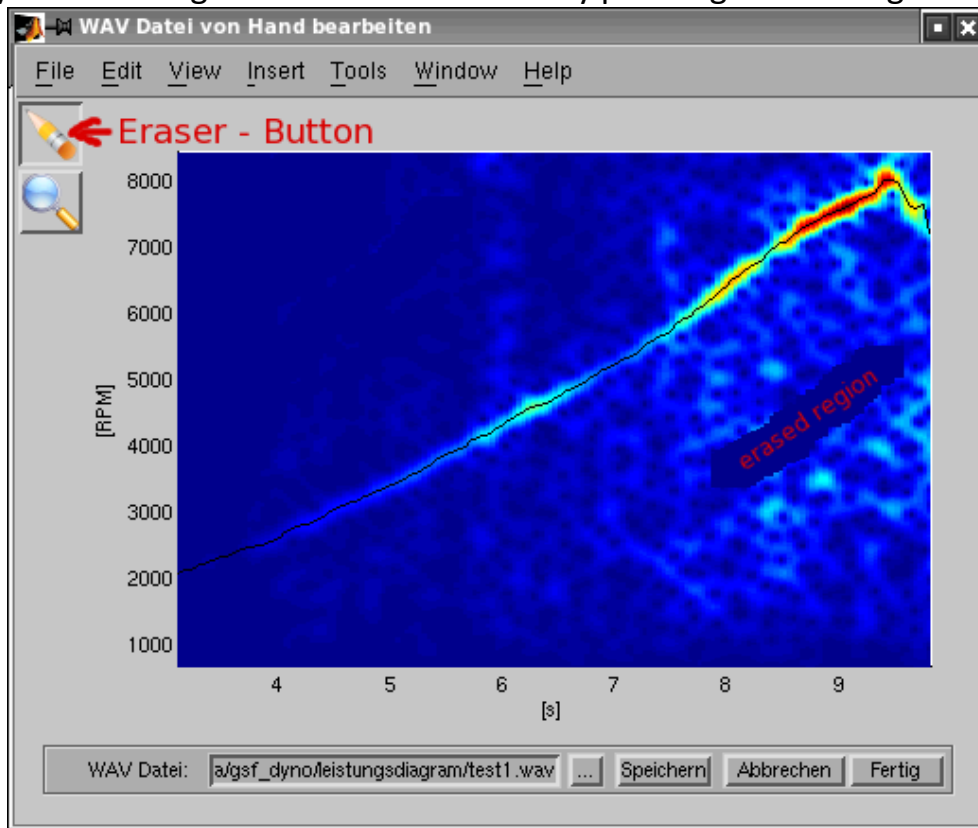
Now we selected finally the still useful range. Nevertheless: The black line shows a somewhat wavelike behaviour, which for sure does not contribute to the accuracy of the measurement. The alternator recordings are usually clearly better.

Here is another example. Microphone recording of a car:
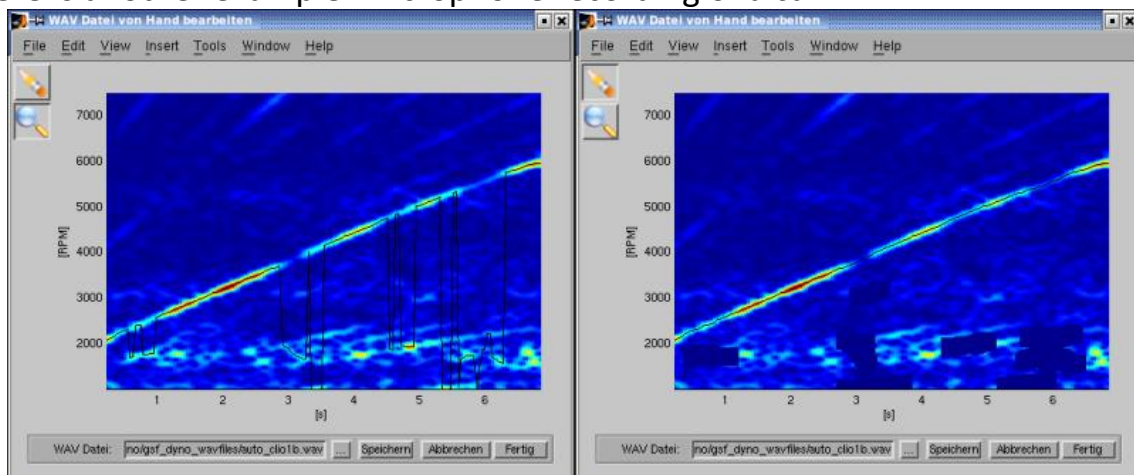
Left part before erasing, right part after erasing.

The Output Figure

In the output windows the results of the analysis are shown. Curves of same type (i.e. same quantity on the x and y-axis) will be displayed in the same window. Every curve gets a description in the left window panel. It shows the maximal values, the climatic correction factor and the comment. The comment is editable and also the colour can be changed again by pressing the coloured button to the left. The visibility of a particular curve can be altered by the checkbox. The zoom function is also working over the axis. Click and pull a box to zoom into the box and click right to zoom out again.

Push the 'Screenshot' button to save the figure in an image file. Supported formats are png, bmp and jpg. If you would like to save the data shown on the graph press 'Export to ASCII'. This file can then be used with other programs.
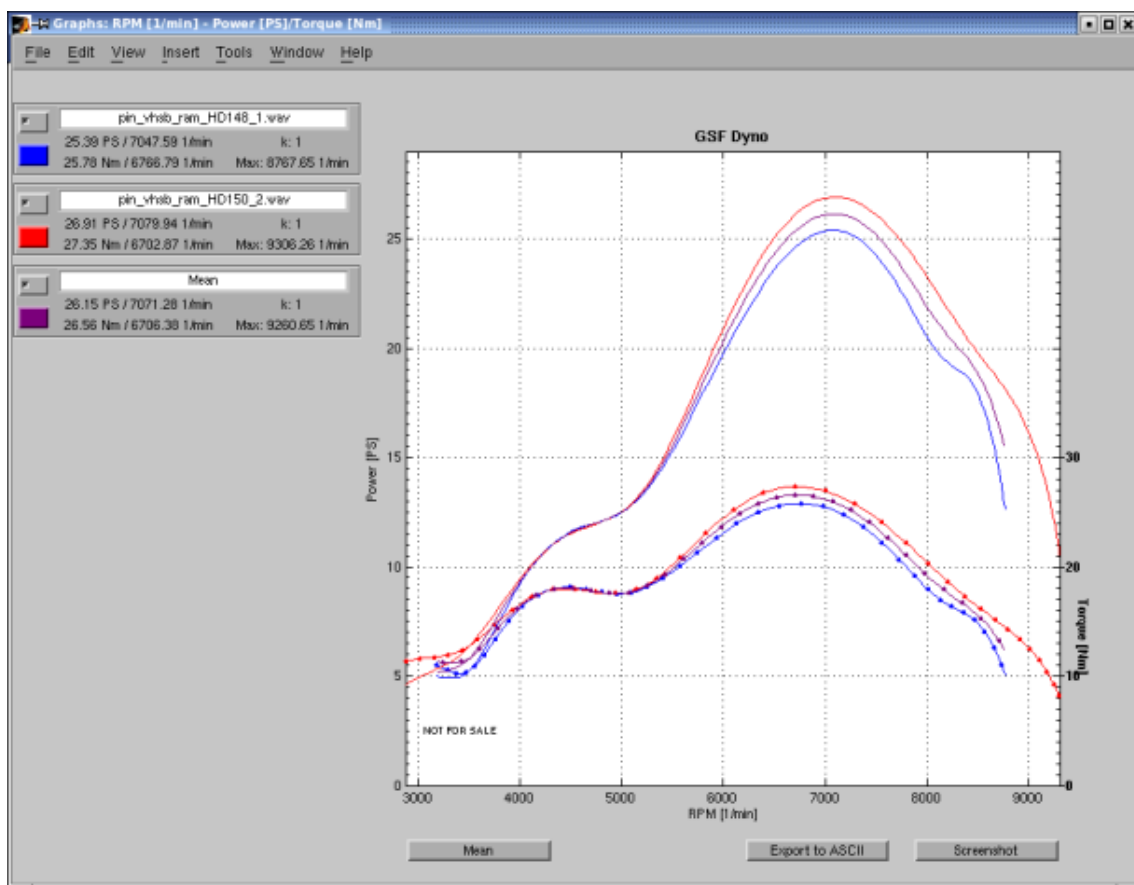
Sometimes it advisable to make two measurements. E.g., if the street goes a bit uphill. Pressing the Mean-Button will calculate the mean over all visible lines on the figure. However, it should be said, that strong discrepancies between the measurements are mainly due to neglected warming-up of the engine.