



SHOCKANALYZER V1.7

USER'S MANUAL

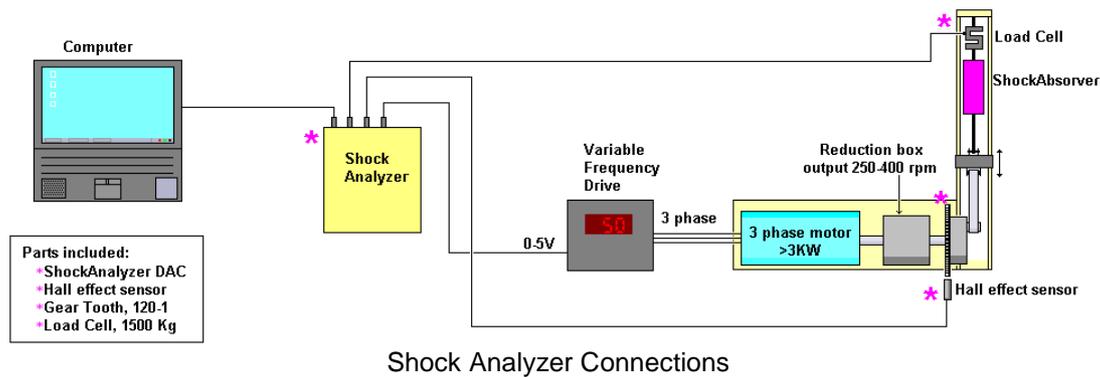
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1. Kit and Installation

The Shock Analyzer Kit consists of a Data Acquisition Unit + Speed Sensor + Gear Tooth (120-1T) + Load Cell sensor to acquire data from a Shock Dynamometer machine.



1.1 Data Acquisition Unit

- **Display:** 16x2 char LCD display:

```
RPM:  0 STOP
CELL:  0 T:---
```

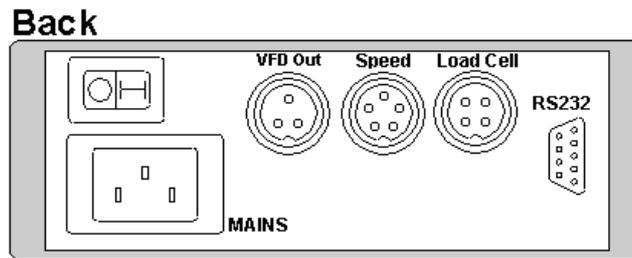
RMP: current speed of the machine.

CELL: Load Cell channel converted to Newtons, it depends on the calibration of the unit.

STOP/RUN, Current data transmission mode. It will be on "run" when acquiring data.

T: Temperature for the thermocouple type K input (usually tied to the shock absorber). Temperature can be in range from 0 to 999 degrees. If there is no sensor connected the reading will be: ---.

1.2 Unit connections



- Mains.** Computer type mains connector. Default voltage is 230 volt, 50/60 Hz. It can be requested for 115 volt too.
- VFD Output.** PWM output for the Variable Frequency Drive. From 0 to 5 Volt.

1	GND
2	PWM Output (0 to 5 volt)
3	8 volt, unregulated

- Speed Sensor.** Hall Effect Sensor

1	5 volt (digital 5 volt)
2	GND
3	Not used
4	GND
5	Signal (active high)

- Load cell,** direct connection to load cell, (amplifier inside the unit).

1	White, Cell IN +
2	Black, GND
3	Red, 5 volt
4	Green, Cell IN -

- RS232.** Serial RS232 connector. 115200 baud, no parity. An USB to serial adapter can be used with computers without serial port. Sportdevices strongly recommend FTDI based adapters.
- Thermocouple type K.** (At front) Input for temperature up to 1000 °C.

1.3 Installation

Very important: when using a *Variable Frequency Drive* (we strongly recommended using a VFD to power the motor) high electric noise pulses are generated and they will strongly affect the old inductive speed sensor. This problem is **completely solved** by using the **new Hall effect sensor** and the provided ground cable (yellow) which connects the machine frame to the yellow plug in the back of the data acquisition unit and the

The speed sensor has to be placed near the provided gear tooth (120-1 teeth) at a distance of less than 1 mm aprox. This sensor is connected directly to the data acquisition unit.



The sensor is thought to be placed horizontally in the machine (3 o'clock = 0 degrees) but if its position is different, it can be configured in the software: "sensor offset". The rotation should be **clockwise**. It can be done by swapping the cables from three-phase motor.

The load cell has to be placed at the upper side of the machine.



When adjusting the upper bar, the user must ensure that the shock absorber can move along all its displacement and it doesn't reach its boundaries because in such case, the force applied to load cell will be very high and it could be damaged.

1.4 How it works?

The device senses all pulses from the speed sensor, and does an analog conversion from the Load Cell channel and the Thermocouple channel for every tooth pulse, and transmits all these data to the computer. Thus the data acquisition frequency is variable with the drum speed. The elapsed time between pulses is also transmitted to the computer to know the speed and the position for the machine at every moment.

When the missing tooth is detected (the elapsed time between teeth is greater than 50% from the last one) N-1 pulses have to be received, if other number of pulses

have been read this is consider as an error, and the computer software discards all the cycle and starts it again, this ensures the data integrity for every cycle.

1.5 Load Cell Calibration.

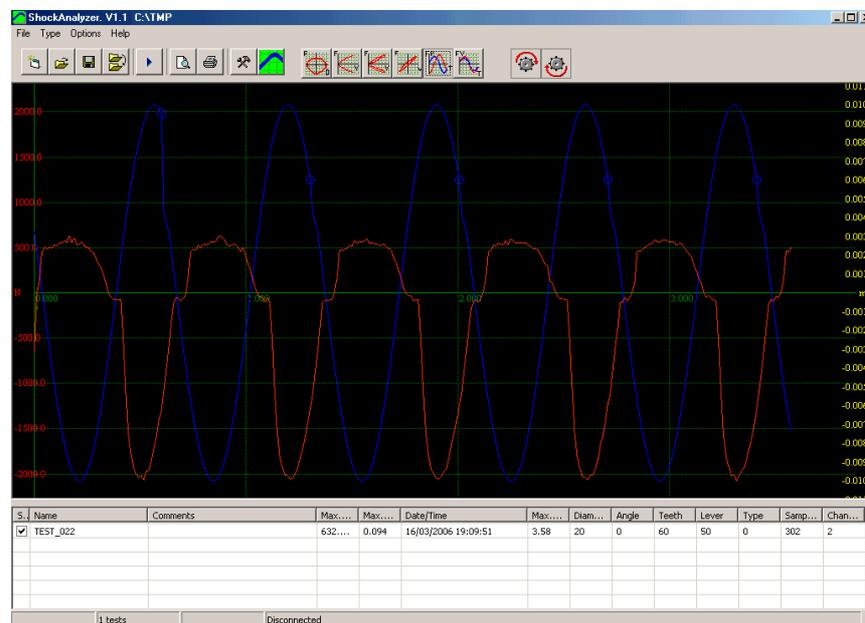
The value shown in the screen is the converted reading from Load Cell in Newtons.

Calibration should be checked for zero load (display=0) and calibration weight (known weight), without the shockabsorber.

It is recommended to use a mass as heavy as possible for each load cell, although it may be difficult to handle. When using lower weights (for example 50 kg for the 450 kg load cell) this may introduce a "scale" error, and the error at end of scale (450 kg) will be unknown.

See section 3 (Load Cell Wizard)

2 ShockAnalyzer Software.



2.1 The Menu

2.1.1 File Menu

File	Test	Options	Help
Remove all			Ctrl+N
Open			Ctrl+O
Change Directory			Ctrl+C
Save as			
Export to Excel			
Export Speed Report			
Preview			F11
Print			F12
Exit			Ctrl+Q

Remove All. It removes all tests from the memory, but not from the disk.

Open. It shows a window to choose the tests to be loaded in memory. It is possible to load them one by one or several at once.

Change directory. It allows changing the directory where tests are automatically saved. Current directory is shown in the title of the window (upper text).

Save as. It allows saving the test with a different name or in a different place.

Export to Excel. This option saves a CSV file (Comma Separated Values) that can be loaded by Excel. This file includes the test header and the pre-processed data for all recorded turns of the test. This data consists of: #tooth, Angle, RPM, Speed (selected units: mm/s, m/s or inches/s), Force (selected units: Kg, N or Lb) and temperature.

Export Speed Report. This option saves a text file with the maximum and minimum speeds for the speed values configured at the "speed_data.ini" file in the installation folder. This configuration file consists of a sorted list of speeds in mm/s.

Preview. It shows a preview in the screen of the tests in the same way as they will appear in the printer.

Print. It prints the selected tests. It shows a window so the user can first choose and configure the printer.

Exit. It exits from the program.

2.1.2 Test Menu

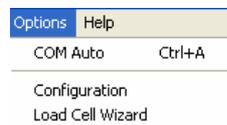


Run (F5). It shows the 'Input Data' window. In this window will enter the data for the test. Then, the user can start the test by clicking over the 'Ok' button.

Remove. It removes the selected test from the program (not from the disk).

Delete. It deletes the test run from the program **and from the DISK**. Be careful.

2.1.3 Options



COM Auto. It will open the 'Automatic COM Port Selection' window. The process will search a data transmission from ShockAnalyzer unit at every port. When it is received it will be shown in green. If none receives data the user should check if there is another program using the COM port, and repeat the process.

It is very useful when used with USB adaptors, where the COM id is a pseudo-random number.

Configuration. It shows a window with the program configuration, it is explained below.

Load Cell Wizard. It opens the Load Cell Wizard window. See section 3.

2.1.4 Help Menu



About. It shows information about SportDevices, developer of the software and manufacturer of the unit.

2.2 The Button Bar



By clicking over these buttons the user can do more quickly the same actions that using the menu. Options are:

- Shinning sheet: New.** File/new menu.
- Open Folder: Open.** File/open menu.
- Disk: Save as.** It saves the test with another name or in another directory.
- Two folders: Change directory.** File/change directory menu.
- Play: Run.** Test / run menu. (F5 key)
- Sheet & glass: Preview.** File/preview menu (F11 key)
- Printer: Print.** File/print menu (F12 key)
- Tools: Configuration.** It opens program configuration window.
- Load Cell: Load Cell Wizard,** see section 3.
- SportDevices icon: About.** Help/about menu.
- Draw Modes Buttons.** See below.

2.3 Draw Modes

2.3.1 FD. Force vs Position

It draws the force versus the direct position reading. It shows a “smile” type graph.

2.3.2 FAV. Force (absolute) vs Velocity

It draws all force curves versus the absolute function of speed. It shows a “C” type graph.

2.3.3 FV. Force vs Velocity

It draws all force curves versus direct speed. It shows a “bended 8” type graph.

2.3.4 FPT. Force and Position vs Time

It draws force and position channels (and temperature) versus time. It shows “oscilloscope” type graphs.

2.3.5 FVT. Force and Velocity vs Time

It draws force and velocity channels (and temperature) vs time. Force is in phase with the speed when the machine pulls from dumper, and uses to be constant when the machine pushes the dumper.

2.3.6 Average ON / OFF.

This option enables or disables the average calculation. When enabled all turns of the same test are averaged to create a single graphs. It increases accuracy and the clearness of the drawing.

2.3.7 Average Loops ON / OFF

TBD

2.3.8 Extend ON / OFF.

When multiple speeds are recorded for a single test, this option expands the speed axis to fit all the curves in the same range, in order to ease the comparison. When expanding the speeds the X axis is no longer referenced to speed, since each sub-test is using a different speed reference.

2.3.9 Temperature ON / OFF

It draws / hides the temperature curves from the tests (if recorded).

2.3.10 Spring analysis

When multiple speeds are recorded for a single test, the first speed sub-test has to be recorded at low speed. This sub-test is used to perform an analysis of the spring behavior of the shock absorber. The resulting line will be displayed over the graphs.

2.3.11 Spring compensation

The spring coefficients analyzed in the previous point are used to subtract the spring effect from the test.

2.3.12 Toggle Load Cell.

This option is used to toggle compression vs extension sides of the load cell force curves.

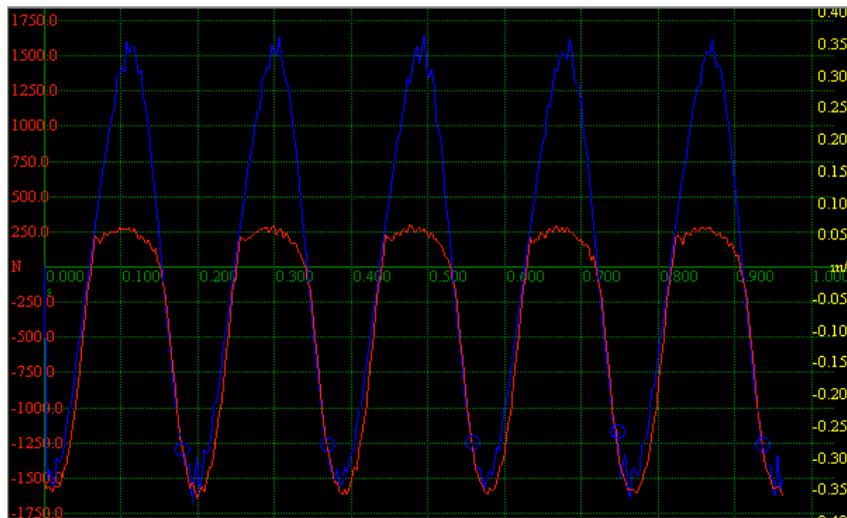
2.3.13 Push cycle

The user can show / hide the push cycle of the graph,

2.3.14 Pull cycle

The user can show/hide the pull cycle of the graph,

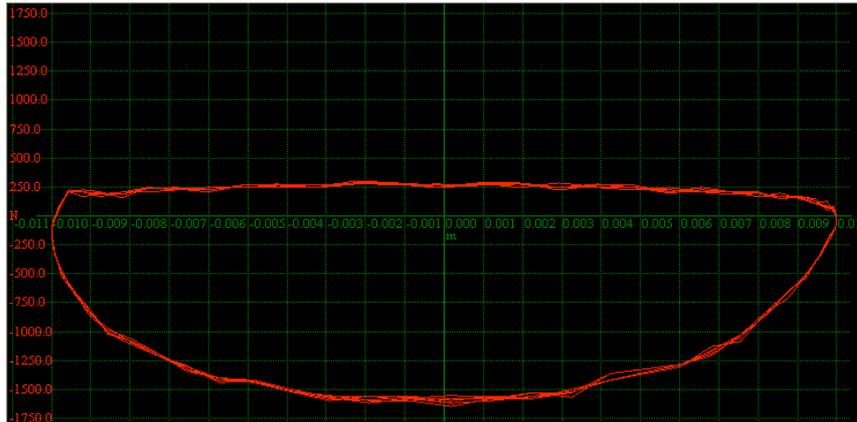
2.3.15 Some Screenshots



Force and Velocity vs Time

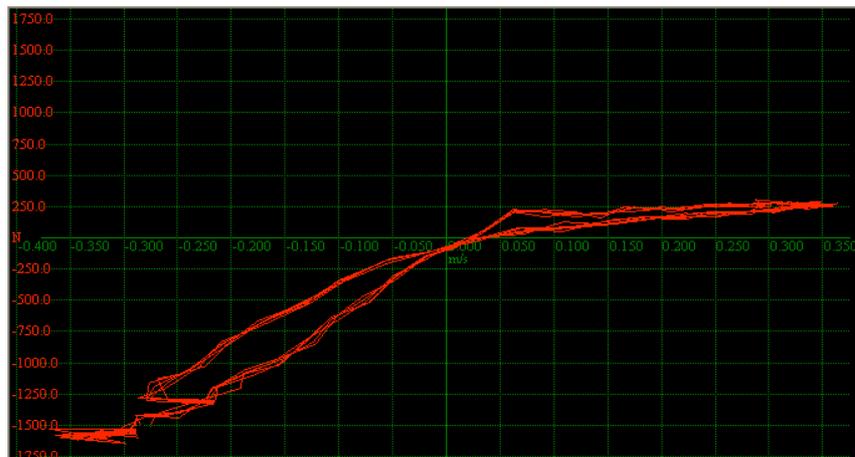
Force is in phase with speed, when the machine pushes the shockabsorber the Force is approximately constant (the shock does not absorb too much power)

When the machine pulls from the shock the force is proportional to speed, the shock is converting energy to heat.



Force vs Position

Position is related with speed, at central position speed is maximum, at upper and bottom position speed is zero.



Force vs Velocity

For positive speed (push) force is close-constant (flat), for negative speed force is proportional to speed.

2.4 Test Columns

See	Name	Comments	V.max (mm/s)	Tension (Kg)	Compression (Kg)	T.max (°C)	Date/Time	Time (s)	Stroke	Angle	Teeth	Connect Rod	offset	K	Type	Samples	Channel	Multitest	Direction	Spring Offset (Kg)	Spring Constant (Kg/mm)
<input checked="" type="checkbox"/>	STD POST FREDDO	no reg	47.2; 134.9; 277.9	77.2; 133.7; 226.1	32.5; 45.2; 66.9	38.8	30/07/2010 6:31:39	19.91	100	-20	120	300	0		0	602	3	2;2;2	-1	15.3	0.003

The following data is shown for every loaded test, by double-clicking over the row the data window will be displayed, and the user can change some of these data

Show, the user can check / uncheck this column to show / hide the test,

Name, name of the test,

Comments, commentaries for the test,

V. max, maximum speed detected during the test (km/h or mph), it supports the sub-test format, example: 47; 134; 277 (mm/s) (each value corresponds to each sub-test, 3 sub-tests in the example)

Tension, maximum force pulling the shockabsorber detected during the test, it supports the sub-test format, example: 77; 133; 226 (Kg) (the program can be configured to Newton, Kg or Pound)

Compression, maximum force pushing the shockabsorber detected during the test. It has the same format as Tension column.

T. Max. Maximum temperature detected during the test (it does not support sub-test format)

Date/Time, date and time when the test was done,

Time, duration of the test,

Stroke, distance that the drum fixing point moves from upper point to the lower point (for the current selected position). The drum in our plans has 10 positions (see below), each one with one angle and stroke.

Angle, angle for the drum position used for the test,

Teeth, number of teeth of the gear tooth, default is 120-1,

Connecting Rod, is the part that connects the shockabsorber to the drum, it size affects to the calculation formula for shockabsorber position when using the "Piston-Crank" type machine.

Offset, is the position of the hall effect sensor. Default position is "3 o'clock" = 0° degrees.

K, not used

Type, type of machine, 0 for "Piston Crank" (default), 1 for Scotch Yoke Slider,

Samples, number of samples read by the unit, (cycles * teeth-1)

Channels, number of channels stored (default = 3),

Multi-test, number of turns of each sub-test. Example: 2; 2; 2; is 3 sub-tests of 2 turns each.

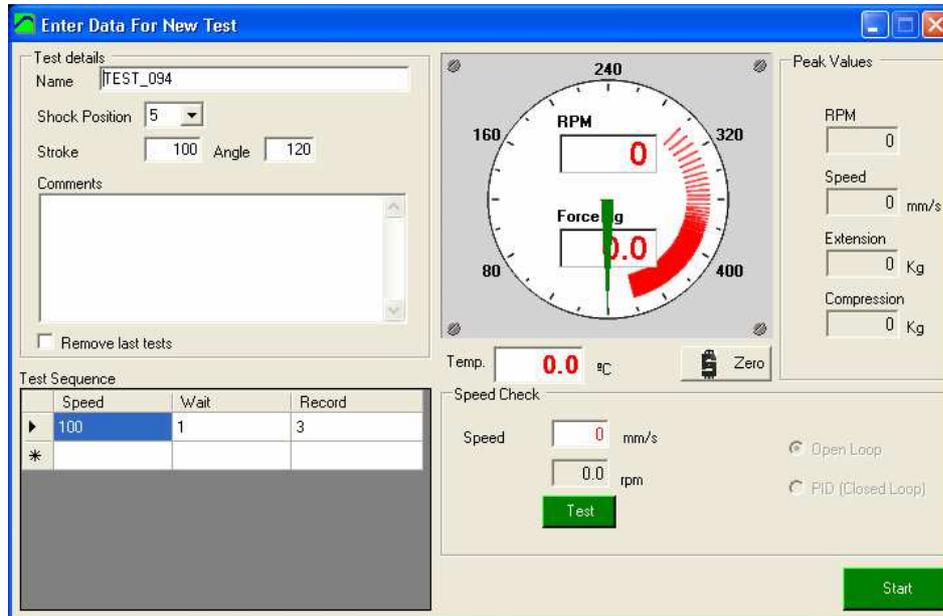
Direction, direction of the rotation: -1 = Clock-Wise, 1: CounterClockWise

Spring Offset, when using the Spring Compensations, this offset is the force of shockabsorber at middle position (approximately 3 o'clock and 6 o'clock drum positions)

Spring Constant, when using the Spring Compensations, this coefficient shows how the spring effect force increases as the shock is compressed. Theoretically, at low speeds the force measurements should be only caused by the spring effect (gas) not to the hydraulic effect, which is related with speed.

2.5 Test Data Window

This window is used to enter data when a new test is going to be recorded.

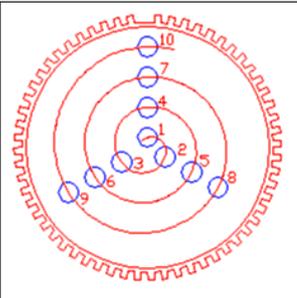


2.5.1 Test Details.

Name. Here the name for a new test has to be entered. The program increases the ending number of test name every time a test is done.

Shock Position. The user has to ensure the selected **position** matches the actual one on the machine.

Position	Diameter
1	10 mm
2	20 mm
3	30 mm
4	40 mm
5	50 mm
6	60 mm
7	70 mm
8	80 mm
9	90 mm
10	100 mm



Stroke and an **Angle**, each position number has associated a **Stroke** and an **Angle** that the program will use to calculate the dumper movement. These values are taken automatically from a table "position.ini" in the program's installation directory.

2.5.2 Test Sequence Table

This table must be filled for all test types: single-speed or multi-speed. When multiple speeds are recorded for a single test, this table is used to enter the different speed steps the motor will perform.

The values entered are:

- **Speed**, millimetres per second. The program provide two methods to calculate the VFD output:

- open-loop, based on the Max rpm on the configuration, which is quite accurate thanks to the internal VFD closed loops.
- Closed-loop, based in a PID implemented on the ShockAnalyzer DAQ (not all Firmware versions support this mode, but it can be updated)
- **Wait**, number of turns to wait before starting to record data, this field is provided to let the motor accelerate up to the desired speed. For low speeds the user can enter 1 turn, and for high speeds 3 turns.
- **Record**, number of turns to record, the minimum is 1.

2.5.3 Peak Values

The program will show in these four boxes the peak values for RPM, Speed, Extension Force and Compression Force during the tests with this window.

Peak Values can be configured to detect the maximum value from all testing interval, or the maximum value for each turn, at Configuration Window (see section 2.7)

2.5.4 Speed Check

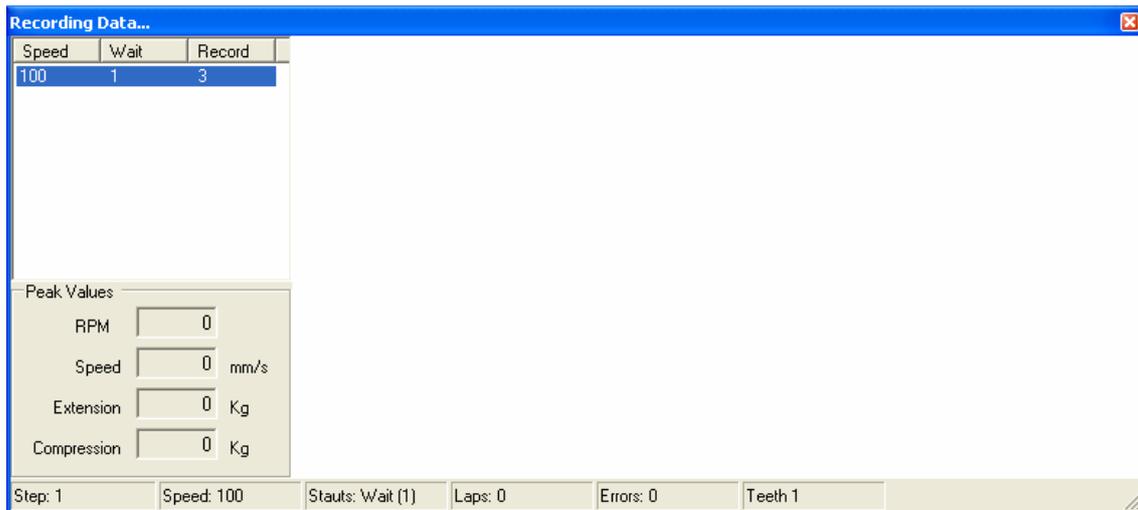
Prior to the recording of the test, the selected speeds (for the Test Sequence Table) can be tested to see if the motor is able to reach that speed, if the max. Speed setting is correct and the open-loop option is working correctly, or the closed-loop settings are correct to reach the desired speed, depending on the method selected for speed control.

Test method consists of:

- Enter the desired speed in mm/s
- Press Test button
- Look at the RPM gauge, and verify the current speed according to the calculated target rpm at the box under speed in mm/s. Speed box in the Peak Values area can also be used to verify the linear speed.
- Press Stop button

Open / Closed – loop setting can also be changed in this window, but for changing their internal settings (max. Speed for open-loop, or PID settings for closed-loop), it is necessary to use the Configuration Window.

2.6 Recording Data



This screen will show the recording process, each new turn is numbered in the right area. If the recording of a new turn fails the program moves the cursor back and overwrites the data for the existing turn with the incoming data.

When all the specified turns and sub-tests have been recorded, then the program automatically exits this window and the Stop Process is started (see section 2.7.2.3).

Peak Values

The program will show in these four boxes the peak values for RPM, Speed, Extension Force and Compression Force during the tests with this window.

Status bar (bottom)

The program shows several data on the status bar:

- **Step:** from the Test Sequence List (for multi-speed tests)
- **Speed:** Current target speed (mm/s)
- **Status:** Wait / Record
- **Laps:** Number of recorded turns
- **Errors:** Number of laps that raised an error (maximum is 3)
- **Teeth:** total number of teeth detected in the last turn. It should match the configured value, if not, then the Errors field is increased and the latest turn data is discarded.

2.7 Program Configuration

Configuration is distributed in four tabs:

2.7.1 Mechanism Type Tab



Dyno Name, name for the reports (print),

Connecting rod, length of the bar used to connect the drum with the sliding bar in which the shockabsorber is mounted (not the drum diameter),

Test Length, maximum number of turns of test recording,

Pickup offset, pickup / hall sensor should be mounted at position 3 o'clock of the drum (0 degrees horizontally). This parameter lets the user compensate its real position.

Piston Crank, (by default) in this machine the mechanism is like into an engine, the created motion is not completely sinusoidal but the program has the mathematical model to calculate it.

Scotch Yoke Slider, this machine creates a perfect sinusoidal motion, but it is more complex to build,

Number of Teeth, number of teeth for the gear tooth, including the missing tooth (by default 120),

Scales, Thermocouple, this value should be kept to 1. It will let the user to setup a different type of temperature sensor.

Thermocouple offset, this value allows to compensate small offset errors in thermocouple. It allows to add or subtract some degrees to the readings.

2.7.2 VFD Tab



This window is used to configure the VFD (Variable Frequency Drive) output which powers the 3-phase motor.

Two control methods are allowed:

- Closed Loop
- Open Loop

2.7.2.1 Closed Loop Control

Some ShockAnalyzer DAQ Firmware Versions include a PID controller to perform the closed-loop (actually it is a P.I. type). Firmware can be upgraded with a program.

Kp value, controls the amount of power applied to the motor according to the difference between the desired speed (target) and the current speed. This difference is called error, and Kp multiplies the error, so $KP=1$ means that error is multiplied by 1 to create the output.

The higher the Kp, the faster the approximation, but a high Kp value could lead to over-oscillations (the target speed is over-passed during the stabilisation, and then the PID removes some power to complete the stabilisation process)

It is recommended to test several values until a good speed response is found, but without oscillations. Anyway the ShockDyno is a relatively slow machine high load due to the shockabsorber effect and does not create high oscillations.

Ki value, controls the final phase of stabilisation. If only using Kp, the final speed will be close to the target speed, but it will not completely reach it, thus Ki performs a final approach (by accumulating the error)

The higher the Ki, the faster the approach, but high Ki values could lead to over-oscillations.

Test RPM, this value is used to observe the closed-loop behaviour.

Test Button, press this button to start the speed test. And press it again to stop the test. During the test a RPM box is displayed on the right-bottom corner to show the current RPM value.

2.7.2.2 Open Loop Control

Max Output RPM, this value is used on the calculation of the linear speed for multi-speed tests. It is the maximum speed of reduction gearbox (with VFD set to 100%).

Press the **Test Button** to see the actual max speed when the output is set to 100%. During the test a RPM box is displayed on the right-bottom corner to show the current RPM value.

Min PWM, this value is used by the program when a slow movement has to be performed, for instance for the Stop Position Feature.

It should be a value low enough to create a slow movement, but high enough to move the machine. A very small value (ex: 1) will create some output, but the motor will not move. The allowed range is 1 to 1023 (1023 = 100% output)

2.7.2.3 Stop Position

Some ShockAnalyzer DAQ Firmware Versions include the Stop Position feature to control the position to stop the machine. Firmware can be upgraded with a program.

Positions: There are four possible positions to stop the machine after a test: Top, Left, Right or Bottom (see figure above).

#Teeth to slowdown, when the output is removed from VFD, it normally performs a deceleration process which will take a few tenths of seconds to stop the machine, during this process a small error in the teeth position is done, so this value is used to compensate that error. The slower the braking speed (Min PWM parameter), the smaller the error.

Shock Position, this value informs to the program about the drum position in which the connecting rod is mounted, in order to do the stop tests.

This is not a configuration value, only a test value. The program will use the current test shock position (at gauge window) every time a new test is finished, to calculate the stop position.

Pos to begin to stop, this is an informative box with the result from using the previous values (stop position, #teeth to slowdown and shock position)

Test button, press this button to start the shockdyno, and press it again to stop it and test the stop position.

2.7.3 Options Tab



Printer Settings:

Colour Printer, when printing in a non-colour printer all curves will use the same colour to ease the visual reading,

Landscape, portrait / landscape, the curves will be printed vertically or horizontally,

Report Type:

- Screenshot, the program will generate a report with the same format as the current display mode selected on main screen
- Detailed, the program will generate a report with a fixed format:
 - Summary of Test data, forces and speeds
 - Force vs Displacement graph
 - Force vs Speed graph

Program Settings:

Language, English, Spanish and Italian languages are available. New translations can easily be done by editing the English.lan file with Notepad, and saving it as "Francaise.lan" for example.

COM Port, all available COM ports on the computer are displayed here. The user can change it manually, or he can use the **COM Auto** function in the Options Menu.

Autosave, (active by default) the program will automatically save every new test. If disabled, the program will ask the user to save the test when the user is going to remove it or exit the program.

Peak Values:

Peak Values can be configured to detect the maximum value from all testing interval, or the maximum value for each turn.

These peak values are shown at Gauge Window and the Recording Test Window.

Units:

International (scientific), Force is shown in Newtons and speed in meter/s

Cegesimal (common), Force is shown in kg and speed is cm/s

Imperial: Force in Pounds and Speed in inches/s

2.7.4 Colours Tab



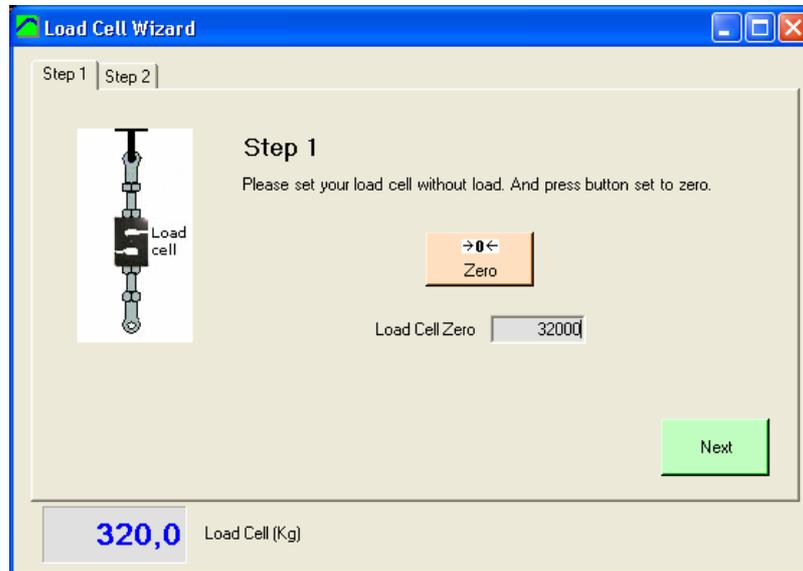
Each channel for each test can have a different colour. The user can edit them on this window. After editing, the **write button** has to be pressed to save the changes.

By default, the program uses **thick lines** (width=2) for Average mode, but this can be configured in this window.

3 LOAD CELL WIZARD

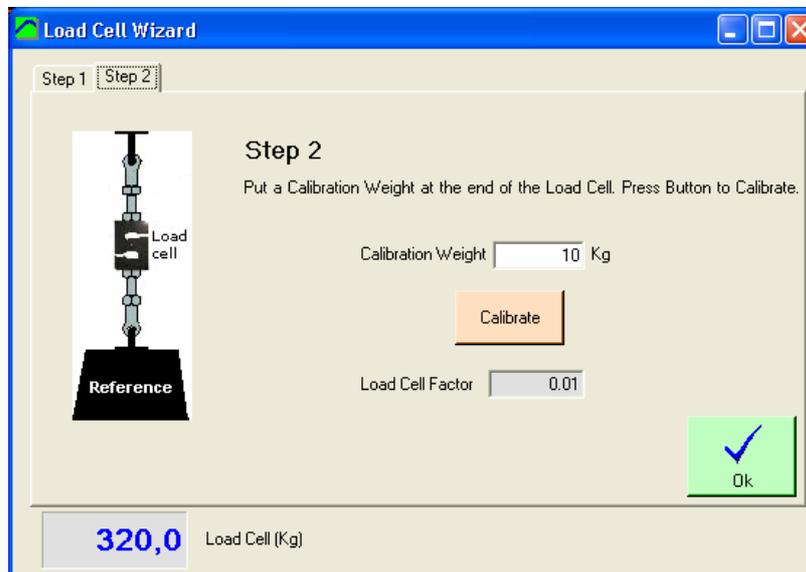
This window eases the Load Cell calibration process. It is divided into two steps:

3.1 Load Cell Zero



With the load cell free, press the “set to zero” button and check the “load cell zero” value is between 30000 and 35000, otherwise there may be some problem on the wiring or ShockAnalyzer DAQ.

3.2 Load Cell Scale



With the calibration weight pulling the load cell, enter the calibration weight value on the white box and press the “calibrate” button.

Check that the load cell reading (blue number, Kg) matches the “reference load” number.

Finally, press **OK** button to finish the calibration process.