SP5 INSTALLATION AND SETUP MANUAL

Contents

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SportDevices
Cami del Port 145, 46470 Catarroja, Spain

2 General Safety Instructions

Use the following safety guidelines to help ensure your own personal safety and to help protect your equipment and working environment from potential damage.

SAFETY: General Safety

When setting up the equipment for use:

- Place the equipment on a hard, level surface. If the equipment is installed in a closed-in wall unit, ensure that there is enough ventilation.
- Avoid placing objects on top of this equipment to permit the airflow required for proper ventilation. Restricting airflow can damage the equipment.
- Keep your device away from radiators and heat sources.
- Keep your equipment away from extremely hot or cold temperatures to ensure that it is used within the specified operating range. (check technical parameters section)
- Keep your equipment away from Electromagnetic emitting devices like CDI ignition, or electric motors / VFD (Variable Frequency Drive)
- Do not push any objects into the air vents or openings of your equipment. Doing so can cause fire or electric shock by shorting out interior components.
- Ensure that nothing rests on your equipment's cables and that the cables are not located where they can be stepped on or tripped over.

When operating your equipment:

- Do not use your equipment in a wet environment, for example, in a wet basement.
- Do not use AC powered equipment during an electrical storm.
- Do not spill food or liquids on your equipment.
- Before you clean your equipment, disconnect it from the electrical outlet. Clean your device with a soft cloth dampened with water. Do not use liquids or aerosol cleaners, which may contain flammable substances.
- Clean the display with a soft, clean cloth and water. Apply the water to the cloth, then stroke the cloth across the display in one direction, moving from the top of the display to the bottom. Remove moisture from the display quickly and keep the display dry.
- Long-term exposure to moisture can damage the display. Do not use a commercial window cleaner to clean your display.

⚠ **CAUTION: Do not operate your equipment with any cover(s) removed.**

- If your equipment does not operate normally - in particular, if there are any unusual sounds or smells coming from it - unplug it immediately and contact an authorized dealer or service center.

⚠ **WARNING: To prevent the spread of fire, keep open flames away from this product at all times.**

2.1 SAFETY: When Working Inside Your Device

Do not attempt to service the equipment yourself, except as explained in your documentation or in instructions otherwise provided to you by SportDevices. Always follow installation and service instructions closely.

2.2 SAFETY: General Power Safety

 By default, if other values are not specified all SportDevices equipment are rated for **230 VAC / 50 Hz.** (115 VAC units will have a specific label for that)

Observe the following guidelines when connecting your equipment to a power source:

- Check the voltage rating before you connect the equipment to an electrical outlet to ensure that the required voltage and frequency match the available power source.
- Do not plug the equipment power cables into an electrical outlet if the power cable is damaged.
- To prevent electric shock, plug the equipment power cables into properly grounded electrical outlets. If the equipment is provided with a 3-prong power cable, do not use adapter plugs that bypass the grounding feature, or remove the grounding feature from the plug or adapter.
- If you use an extension power cable, ensure that the total ampere rating of the products plugged in to the extension power cable does not exceed the ampere rating of the extension cable.
- If you must use an extension cable or power strip, ensure the extension cable or power strip is connected to a wall power outlet and not to another extension cable or power strip. The extension cable or power strip must be designed for grounded plugs and plugged into a grounded wall outlet.
- If you are using a multiple-outlet power strip, use caution when plugging the power cable into the power strip. Some power strips may allow you to insert a plug incorrectly. Incorrect insertion of the power plug could result in permanent damage to your equipment, as well as risk of electric shock and/or fire. Ensure that the ground prong of the power plug is inserted into the mating ground contact of the power strip.
- Be sure to grasp the plug, not the cable, when disconnecting equipment from an electric socket.

2.3 SAFETY: If Your Device Gets Wet

⚠ **CAUTION: Before you begin any of the procedures in this section, see the SAFETY: General Safety section of this document.**

⚠ **CAUTION: Perform this procedure only after you are certain that it is safe to do so. If the device is connected to an electrical outlet, turn off the AC power at the circuit breaker, if possible, before attempting to remove the power cables from the electrical outlet. Use the utmost caution when removing wet cables from a live power source.**

1. Disconnect the AC cord from the electrical outlet, and then, if possible, disconnect the AC cord from the device.
2. Turn off any attached external devices, then disconnect them from their power sources, and then from the device.
3. Contact SportDevices support (info@sportdevices.com)

⚠ **Limited Warranties:** warranty is limited to normal usage of the device, any fault caused by inappropriate usage or accident will not be covered

2.4 SAFETY: If You Drop or Damage Your Equipment

⚠ **CAUTION: Before you begin any of the procedures in this section, see the SAFETY: General Safety and Power Safety sections of this document.**

4. **CAUTION: If any internal components can be seen through damaged portions, or if smoke or unusual odors are detected, disconnect the device from the electrical outlet and contact SportDevices support** (info@sportdevices.com)

1. Save and close any open files, exit any open programs, and shut down the computer.
2. Turn off the device and disconnect from the power source, and then disconnect from the computer.
3. Turn off any attached external devices, and disconnect them from their power sources and then from the computer.
4. Connect the device to the power source and turn on the device.
5. If the device does not start, or if and smoke or unusual odors are detected, or you cannot identify the damaged components, contact SportDevices support.

2.5 Protecting Against Electrostatic Discharge

⚠ **CAUTION: Disconnect product from mains power source in accordance with product specific safety information located on the "Safety Information" section of this website.**

Electrostatic discharge (ESD) events can harm electronic components inside your device. Under certain conditions, ESD may build up on your body or an object, such as a peripheral, and then discharge into another object, such as your device. To prevent ESD damage, you should discharge static electricity from your body before you interact with any of your device's internal electronic components, like the Bluetooth plug-in.

You can protect against ESD and discharge static electricity from your body by touching a metal grounded object (such as an unpainted metal surface on your device) before you interact with anything electronic.
You can also take the following steps to prevent damage from electrostatic discharge:

- When unpacking a static-sensitive component from its shipping carton, do not remove the component from the antistatic packing material until you are ready to install the component. Just before unwrapping the antistatic package, be sure to discharge static electricity from your body.
- When transporting a sensitive component, first place it in an antistatic container or packaging.
- Handle all electrostatic sensitive components in a static-safe area. If possible, use antistatic floor pads and work bench pads.

2.6 Dynamometer Important Safety Tips

- Securely fasten test vehicle using all available restraining ratchet straps. The more straps the better. Secure both front to back and side to side. Never move the steering wheel for front wheel drive vehicles while under test.
- Always inspect vehicles for fuel or oil leaks before testing as dyno electrical system can ignite fuel
- Always perform low speed test run to confirm vehicle is adequately secured and operational before doing extensive testing.
- Keep people away from the dyno test area and NEVER have people stand behind the rear of the vehicle. Debris may be stuck in the tires tread and may become projectiles during testing.
- When operating around rotating parts do not wear loose fitting clothing as they may get caught up in rotating pulleys or mechanical components
- Keep dyno area clean from all loose objects
- Keep all hands, feet, and other objects away from moving rolls during tests
- Always wear approved safety equipment such as eye protection and steel tow boots around dyno area
- The dynamometer rollers and power absorption units can become very hot during testing. Avoid contact with them as serious burns or injury can occur.
- The dynamometer power absorption units require high voltage DC current to operate.
- Contact with the high power electrical wires and boxes may be fatal. Disconnect all power to the electrical system before inspecting or servicing.
- During extended testing vehicle cooling system and engine may become very hot.
- Extreme caution is necessary when working near these components.
- Always inspect vehicle tires for wear or damage before testing and only operate with tires that are in good condition and at the proper tire pressure. FOR ALL TIRES TIRE PRESSURE SHOULD BE BETWEEN 1.8 to 2.5 bar (25-35 PSI)
- Never let untrained personal operate the vehicle during dyno testing
- Exhaust gasses are poisonous and may be fatal.

2.7 Technical Specs

- Supply Voltage 230 Vac (optional 115 Vac, when specified in label)
- Power Consumption: max 6 W
- Working Conditions: Temperature: -10ºC to 40ºC, humidity < 90%
- Storage Conditions: Temperature: -20ºC to 80ºC, humidity < 80%
- Provided supplies:
  - 5 V-sensors (max 100 ma)
  - 5V-load cells (max 50 ma)
  - 12 V-relays (max 200 ma)

3 SP5 Installation

3.1 Introduction

The SP5 System consists of a Data Acquisition unit (DAQ) with two complete Roller control channels, each Roller Control Channel consists of:

- Roller speed measurement (hall effect sensor),
- Load Cell channel (brake torque measurement),
- Brake Control output channel

SP5 can be used to automate most functions on a dyno room (engine test bed) or to control a vehicle dynamometer.
It has several inputs and outputs to acquire data from the engine and to control the brake(s) and other parts of the installation.

SP5 Kit includes:

- SP5 DAQ unit
- Hall effect sensor to read speed from one roller or from brake
- Capacitive and Inductive clamps, for reading Engine RPM
- Load cell for acquiring brake torque (several models available)
- Brake Power Supply: Input 230 Vac, Output: 200 Vdc, 23 Amp, control based on current.
- USB to Serial adapter. Note that serial COM still has more immunity against electric noise than USB (specially with 2 stroke engines), for this reason we prefer to have the serial cable as long as possible, and USB part close to the computer.
- Installation Cables
- Software CD

3.2 Dynamometer Installation.

Two basic types of dynamometers can be controlled with SP5:

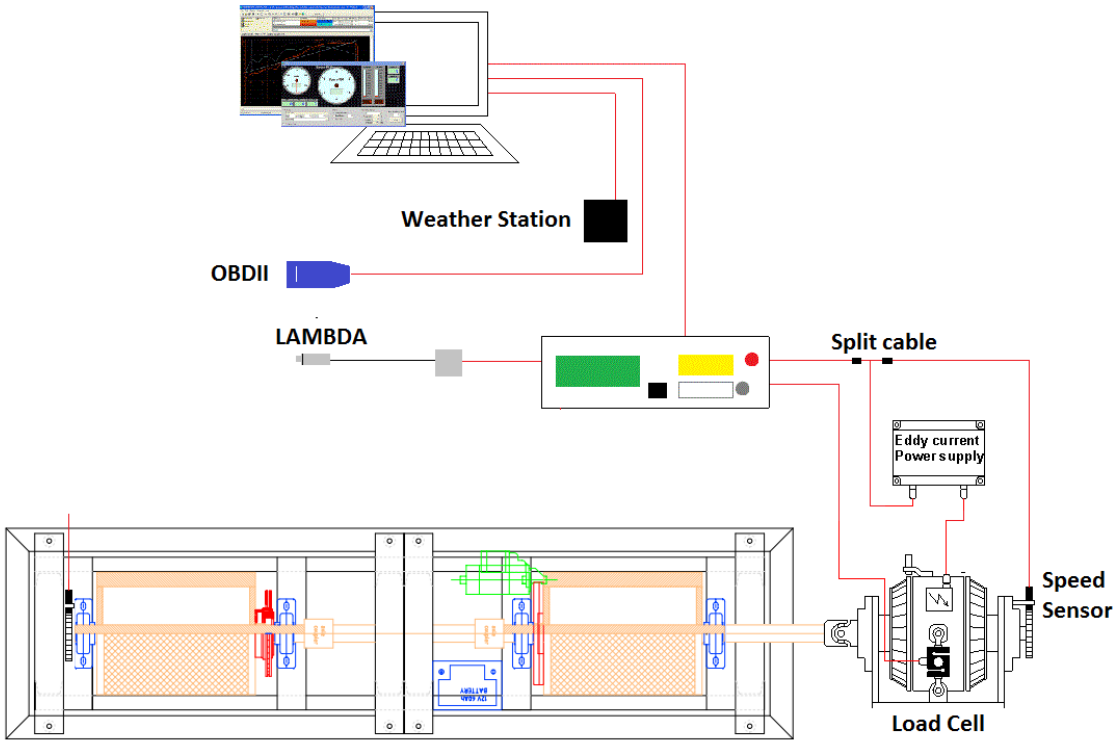
- On vehicle dynamometers, SP5 performs basically data acquisition and speed control on the dynamometer roller(s). Normally SP5 is not used to control the vehicle operation, as the user can actuate directly over start, throttle, clutch, etc.

- On engine test bed dynamometers, SP5 in addition of Data Acquisition and speed control, can also perform control over several parameters of the engine as engine start, fans, throttle, etc. And the installation can be splitted in a dyno room and a control room to allow the user to operate the engine in a safer and more comfortably way.

3.2.1 Rolling Road dyno installation

SP5 can be used on several types of rolling road dynamometers:

- Motorbike (single roller)
- Car, 1 axle, single roller per wheel (or long single roller)
- Car, 1 axle, twin roller per wheel (brake is mounted on the front rollers)
- Car, 2 axle, single or twin roller per wheel, but only one axle at once
- AWD Car: 2 axle, both axles operating at once. Note that this requires a specific Firmware license activation.
- Other dynos based on rollers, with a maximum of 2 speed sensors



Note: speed sensor can be mounted on rollers or at brake

Although several sensors are connected typically to SP5:

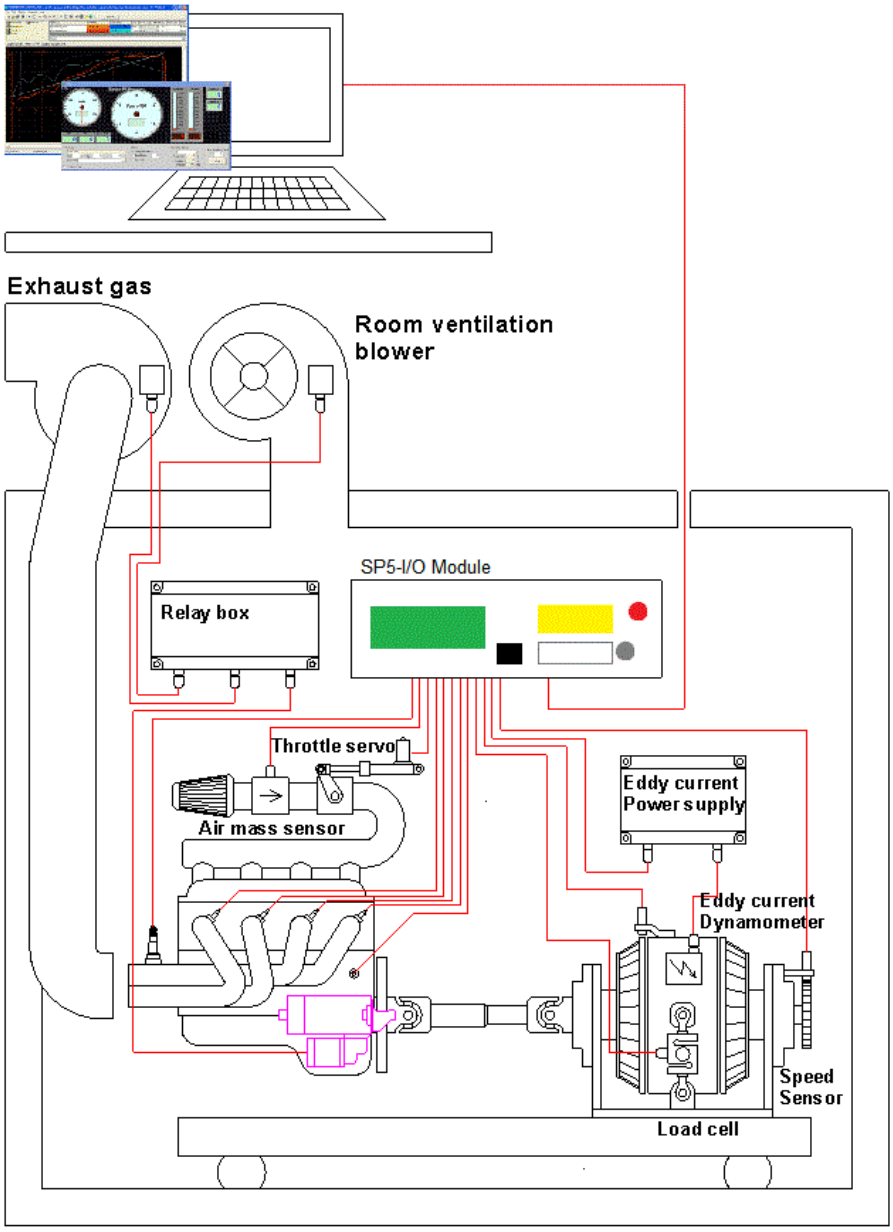
- Lambda (with external controller)
- Thermocouples (water, exhaust, etc) (up to 8)
- Other analog signals (up to 6)

Other devices are connected directly to PC:

- USB Weather Station
- USB OBDII Interface
- Serial Exhaust Gas Analyzer

Engine Test bed dyno installation

Below is shown a typical dyno room controlled with SP5:



Note: SP5 can be installed close to the dyno / engine to shorten all data and control cables, and then only the serial cable will have to go through the wall to the computer. All control tasks will be performed from the computer, although for safety critical actions (as turning the engine ignition OFF) it is recommended to have an extra switch in series, at the control room.

3.3 Proposed installation parts.

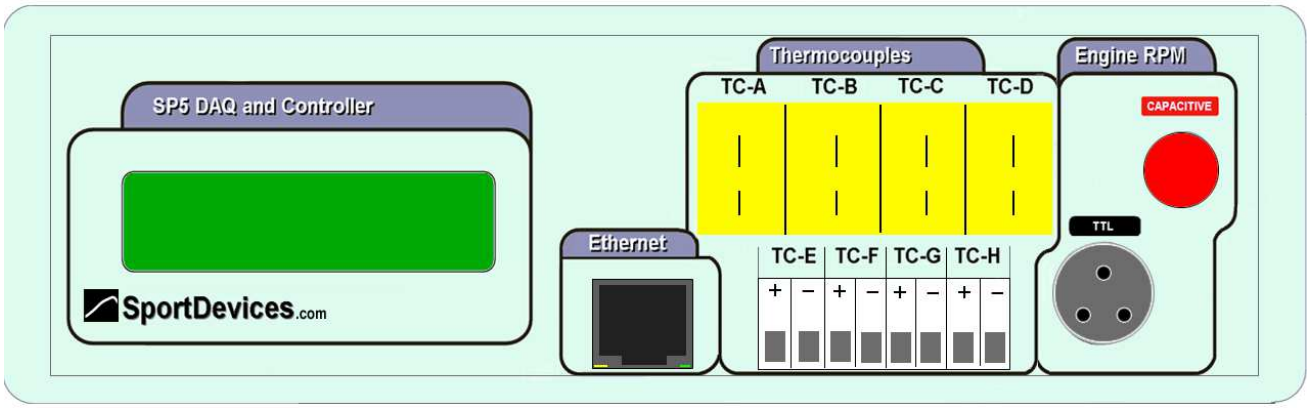
- **SP5 DAQ module.** This unit provides both Data Acquisition and Speed Control functions.
- **Computer.** Any modern computer with Win XP, Win7, Win8, and Win10 will work.
- **USB-Serial adapter**, it is included with the kit
- **Hall Effect Sensor(s).** This sensor(s) is used to read the roller speed (rolling road dynamomer) or brake speed (engine test bed)
- **Gear Tooth.** Installed on the roller or at the eddy current brake to read its speed. Minimum recommended is 8 teeth and maximum 150.
- **Load Cell.** Reads the brake force / torque. Typical values are 300 kg for motorcycle dynos 500 kg for car dynos, but it is recommended to do the math for each dyno.

- **Eddy Current Brake.** 192 volt rated. There are two common models rated for 15 Amp, and 23 Amp (other models exist).
- **Brake Power supply:** Current models PWS1.5, 3.1, 3.2 and HS-PWS implement the brake control by controlling the brake current. Model 1.5 may need to adjust its current scale to each brake.
- **Throttle Servo [optional].** A high torque RC servo can be used to drive the throttle.
- **Ignition and Starter Relays [engine test bed].** 12 volt relays to control the engine. Additional relays can be controlled with the SP5 to control the fans on the room.
- **Fans / Turbines.** Some type of fans or turbines may be necessary for the following functions:
    - Feeding fresh air intake with from outdoor (air inside the room gets hot quickly) this turbine should be very high power (>2 KW, or >5KW) and high speed to simulate on-track conditions, a variable speed driver is recommended + frequency to voltage converter to use the air speed. SP5 has a PWM output called “air-speed” that can control the speed of the air turbine as a function of roller/engine speed.
    - Exhaust extraction, first segment of this tube should be made with iron or steel because the high temperature of exhaust gas.
    - Engine cooling, engine should by cooled by a fan, a car's fan or a truck's fan can be used with a thermostat to ensure the coolant will be at a right temperature all time. A heat interchanger may be also used to increase cooling efficiency.
    - Engine and exhaust pipes cooling, when running on the track the exhaust pipes are being cooled as the vehicle runs, but when working on the dyno they may get too hot and can be damaged. For instance titanium exhaust pipes cannot work at high temperatures.
- **(VFD) Variable Frequency Drive [optional].** It is recommended to control air-intake turbine.

3.4 SP5 Connections

3.4.1 SP5 Front Panel

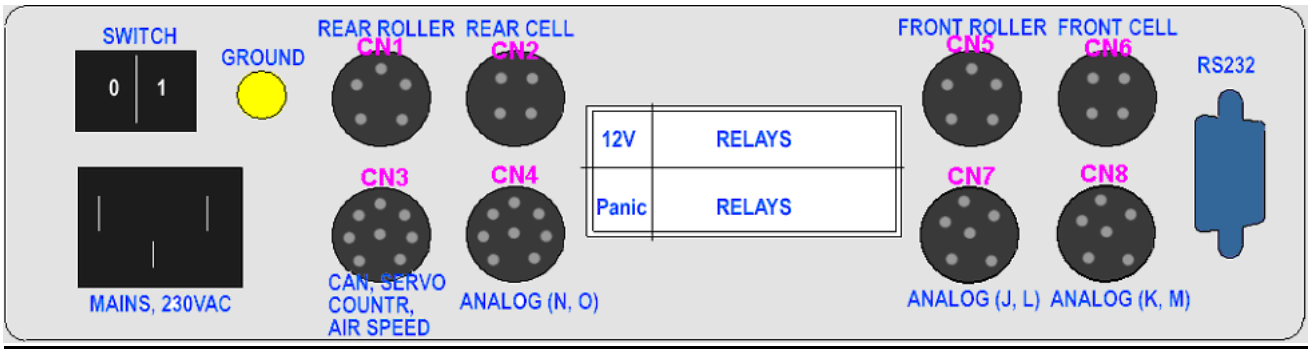
Front panel has the following Connectors:



1 x Ethernet Connector (100 Mbit)
4 x Type K Thermocouple Yellow Connectors, up to 1000ºC (keys A, B, C, D)
4 x Type K Thermocouple Screw Connectors, up to 1000ºC (keys E, F, G, H)
1 x TTL Ignition RPM input (3-pin) the inductive clamp (black) is connected here
1 x Capacitive RPM Input (Red) capacitive clamp (red) is connected here

3.4.2 SP5 Rear Panel

Rear Panel has the following Connectors:



1 x Mains 230 VAC / 6W Power Input
8 x Round Connectors:

- 2 x 5-pin Connectors for **Roller, Brake Output** and Start/Stop Switch
- 2 x 4-pin **Load Cell** Connectors
- 2 x 8-pin Connectors (Left): CAN, AirSpeed, Servo Output, 2 Analog Inputs (0 to 5 volt)
- 2 x 8-pin Connectors (Right): Main 4 x Analog Inputs (lambda, etc) (0 to 5 volt)

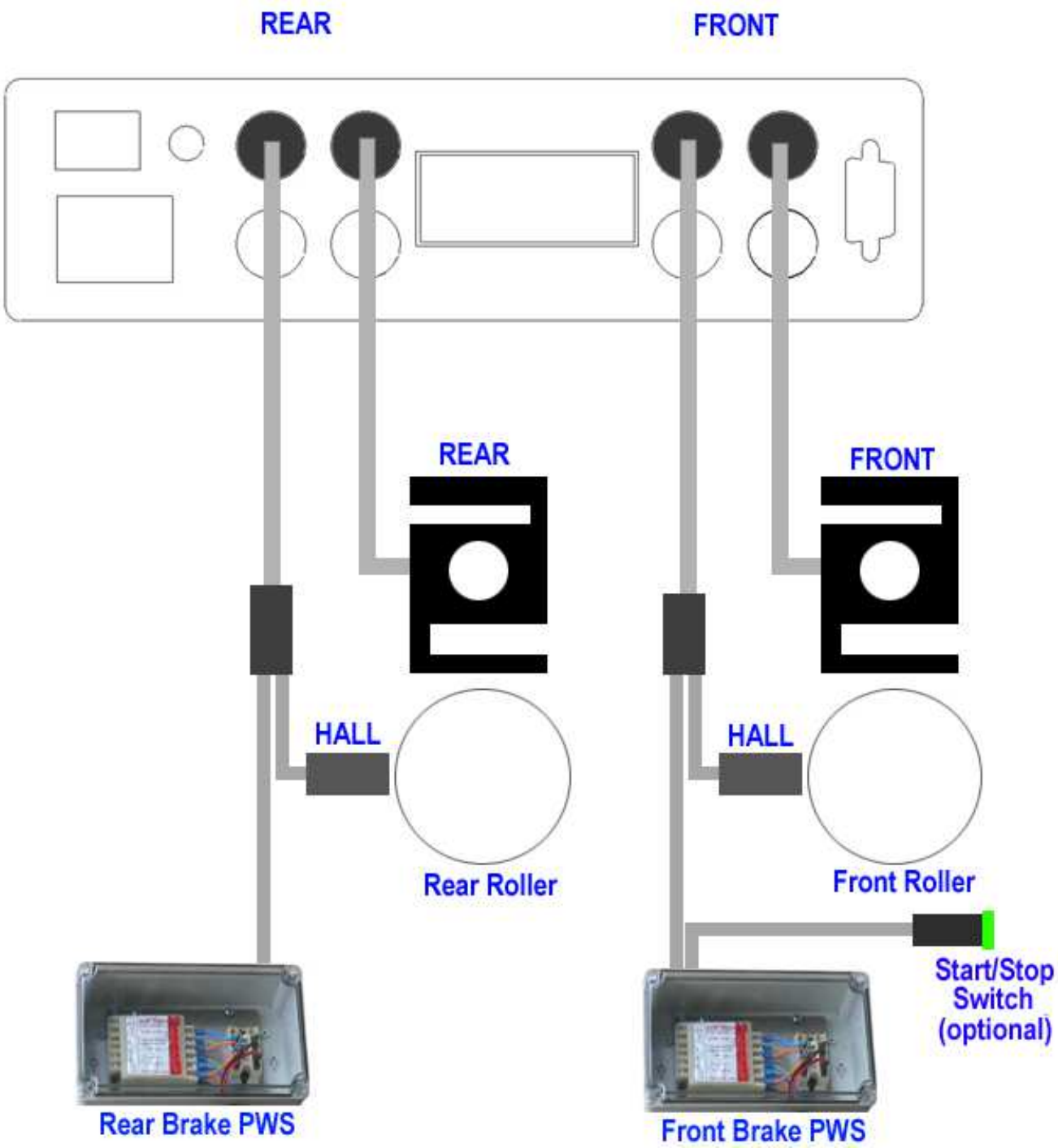
1 x RS232 Serial connector to computer (115200 baud, no parity, 1 stop bit)

20 x Screw Connectors:

8 x 12 Volt Relays outputs
1 x 12 Volt Power (input)
1 x “Panic” (Emergency Stop)

3.4.2.1 Basic Dynamometer Connections

(Rollers, Load Cells, Brake Power Supplies, Start/Stop Button)

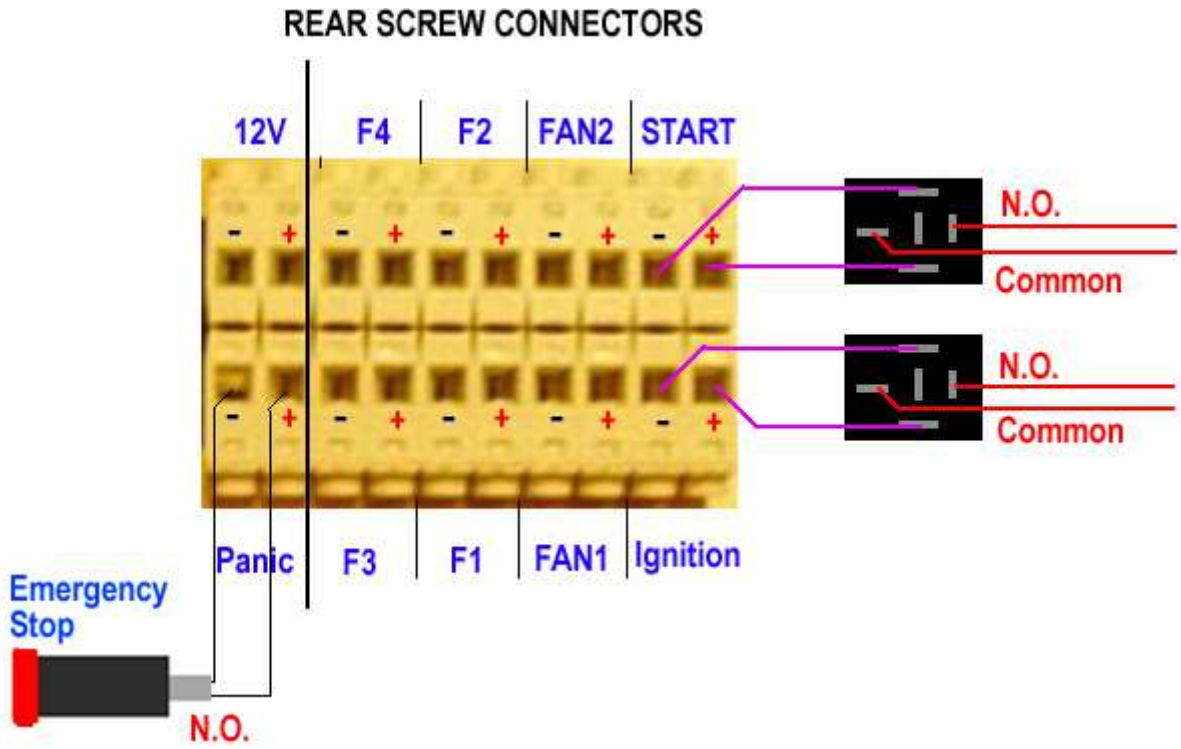


3.4.2.2 Relays Connections

There are 8 Relay Outputs. Each relay output consists of an Open Collector line (-) and a 12 Volt Positive line which are intended to drive low power 12 volt relays / 100 ohm approx.
The maximum power deliverable by the SP5 is about **500 mA**, this means that not all the eight relays can be powered at same time. In practice, most dynamometers need 2 or 3 relays, so the provided power will be enough, depending on the relays consumption, 3 relays may cause the 12 volt to fall.
If all relays were necessary to be powered at same time, an **external 12 Volt Regulated Power Supply** must be connected to the 12V input. Note that polarity of PWS must be kept.

Normally the terminals Normally Open and Common are used on the relays for some of the following functions:

- Power the ECU/CDI of the vehicle (ignition output)
- Operate the starter Relay of the vehicle (the small relay operates a bigger relay, not the starter motor)
- Cooling Fans
- Other actuators such as an elevator to ease the vehicle to entering/going out from twin rollers



Emergency button is a Normally Open Switch that can be connected to the “panic” terminals. Polarity does not matter. When pressed the SP5 will apply a pre-defined brake torque to the rollers until they are stopped (switch can be released before the rollers are stopped)

3.4.2.3 CN1 and CN5 Connectors (Rollers)

1 – **5V**
2 - GND
3 – Start / Stop Switch (active LOW)
4 – Brake output (PWM 0 to 5 volt, 2.4 KHz)
5 – Roller input (0 to 5 volt pulses)

3.4.2.4 CN2 and CN6 Connectors (Load Cells)

1 – Cell (-), SP5 uses two 24-bit ADCs with built-in amplifier
2 - GND
3 – **5V** (max 50 ma total)
4 – Cell (+)

3.4.2.5 CN3 Connector (Digital)

1 - GND
2 – CAN H (not active)
3 – Servo. By default this output is PWM 0 to 5 volt, but can be configured to work with Radio-Control servos (1 ms + 0.5 ms @ 50 Hz),
4 – **5 V** (max 20 ma)
5 – External low speed counter (0 to 5 volt pulses)
6 – CAN L (not active)
7 - GND
8 –**[Rev 2.1+]** : **12 V** (max 100 mA in total), **[Rev 2.0]:** Airspeed (PWM 0 to 5 volt, 2.4 KHz)

3.4.2.6 CN4 Connector (analog)

1 - GND
2 – **[Rev 2.1+]:** AirSpeed, **[Rev 2.0]:** Reserved
3 – **[Rev 2.1+]:** Servo (same signal as CN3), **[Rev 2.0]:** Reserved
4 – **5 Volt** (max 20 ma)
5 – Analog 6 (0 to 5 volt) (channel 0x4F / 'O' in Sportdyno)
6 – Analog 5 (0 to 5 volt) (channel 0x4E / 'N' in Sportdyno)
7 - GND
8 - **12 Volt** (max 100 mA in total)

3.4.2.7 CN7 Connector (analog / Lambda 1)

1 – GND
2 – Analog 3 (0 to 5 volt) (channel 0x4C / 'L' in Sportdyno)
3 – **5 V**
4 – Analog 2 / **Lambda 1** (0 to 5 volt) (channel 0x4A / 'J' in Sportdyno)
5 – GND
6 – **12 V** (max 100 mA in total)

3.4.2.8 CN8 Connector (analog / Lambda 2)

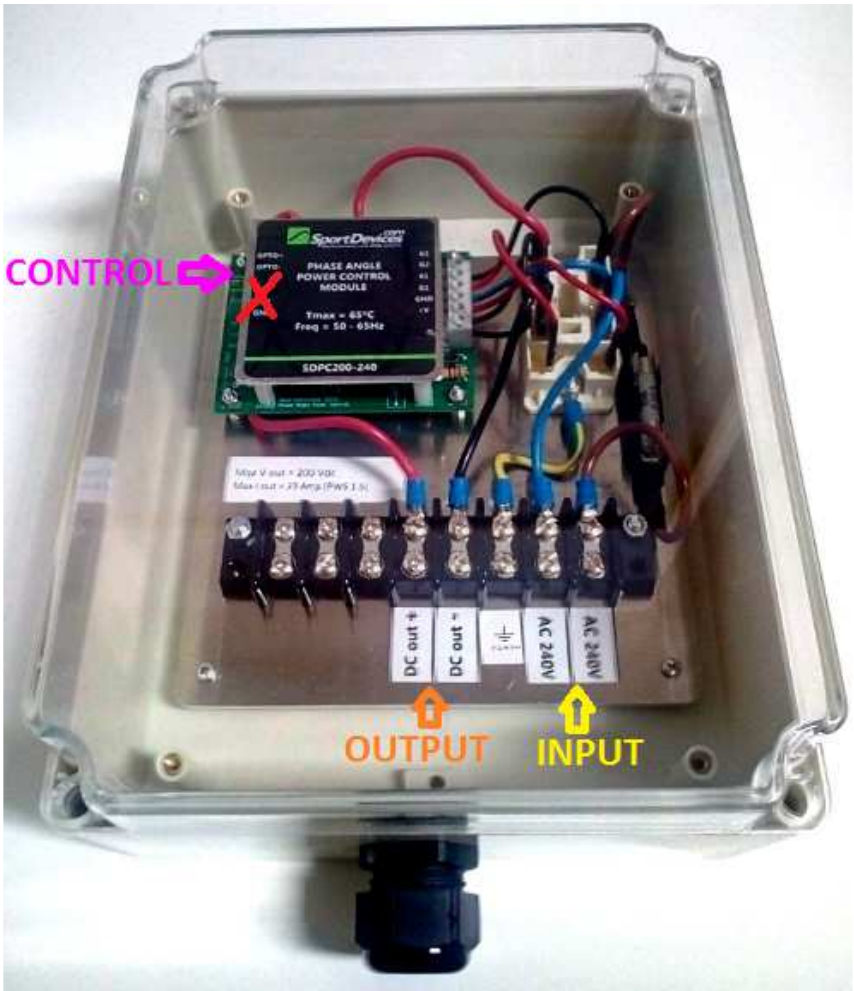
1 – GND
2 – Analog 4 (0 to 5 volt) (channel 0x4D / 'M' in Sportdyno)
3 – 5 V
4 – Analog 2 / **Lambda 2** (0 to 5 volt) (channel 0x4B / 'K' in Sportdyno)
5 – GND
6 – **12 V** (max 100 mA in total)

3.5 Power Supply

Please refer to Power Supply Installation and setup manual.

Installation of Power Supply (1.5) consists of connecting the following lines:

- Input power lines: 230 volt 50/60 Hz.
- Output power lines: 200 Vdc max, 23 Amp
- Control cable, a split cable is provided to get the brake control signal from the 5-pin connector
- **IMPORTANT**: **Do not use 5V, I/P and GND lines**, these lines are not isolated from mains line and will cause severe damage to SP5 or computer. They are only used for testing purposes



4 SportDyno Setup Guide

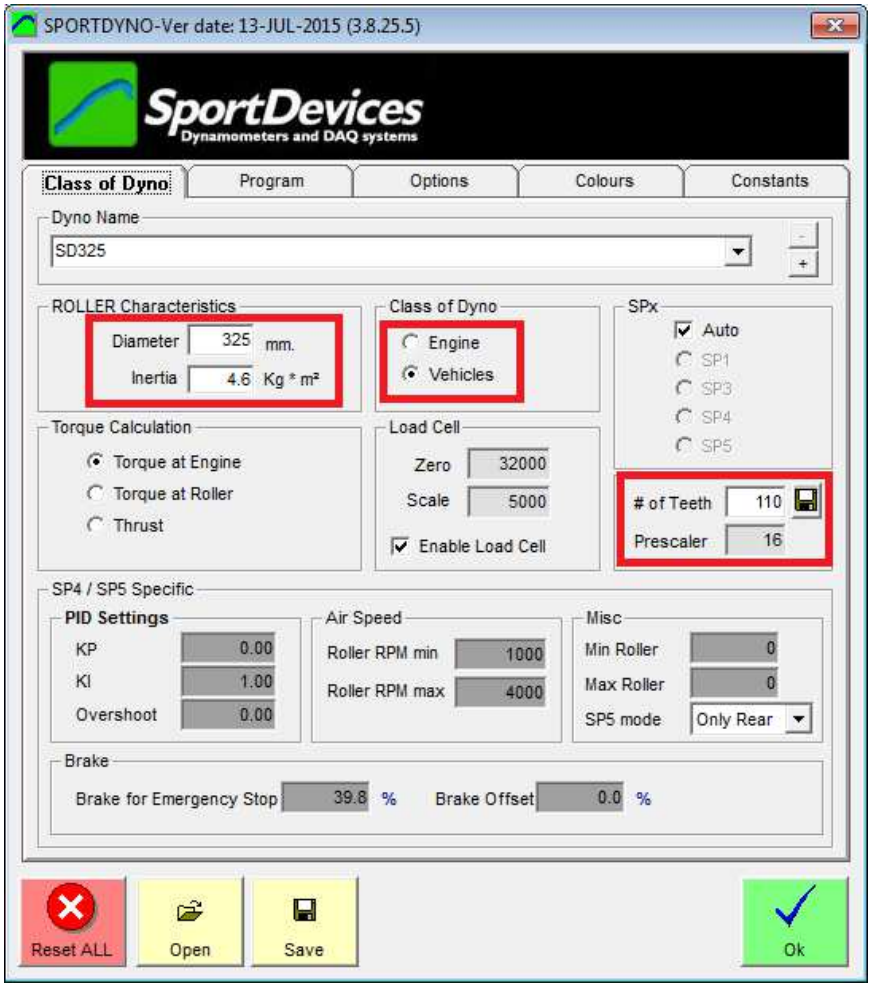
Configuration can be divided into 4 phases:

- Inertial configuration: roller(s) and pulses
- Ratio configuration, for manual modes this step may be necessary to be repeated for each vehicle, engine, or gear used.
- Load Cell configuration, this process can be performed at the end
- Speed Control Configuration

4.1 Inertial Configuration: Roller / Flywheel

Setup all roller / dyno data at “Config / Class of Dyno” Window

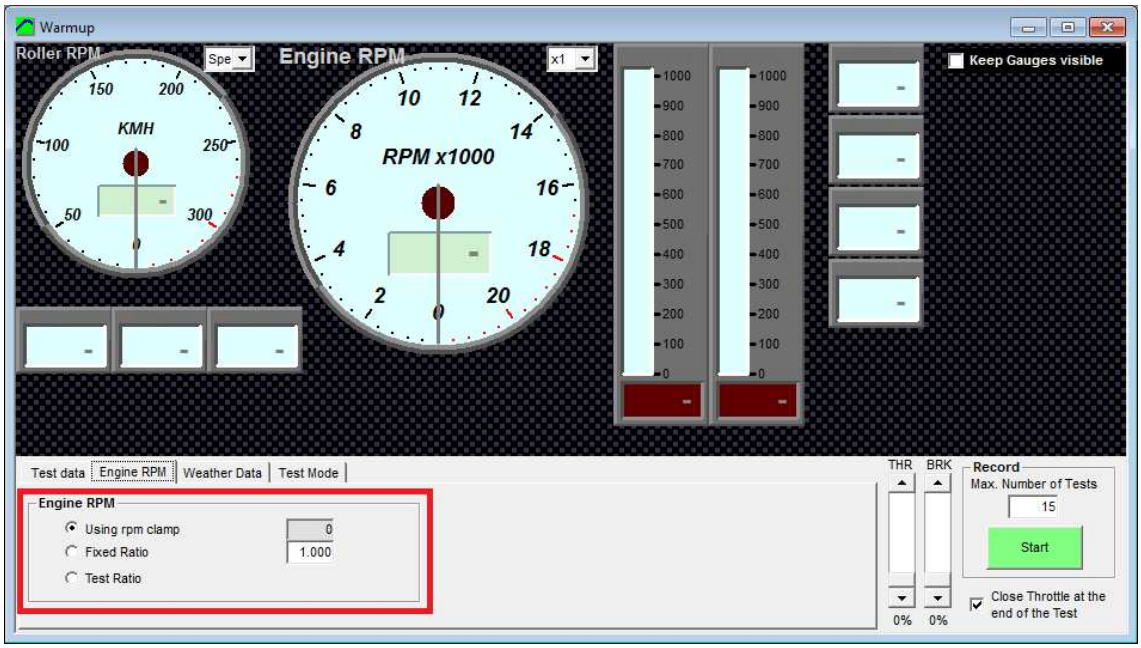
- Dynamometer **type**: Vehicle Dyno or Engine testbed
- **Roller Diameter**
- **Roller Inertia**
- Number of **Teeth** for gear tooth. Note: recommended from 80 to 150 teeth
- **Prescaler**: always 1 for SP5
- Set “SP5 mode” to “Only Front” by default.



4.2 Ratio Configuration

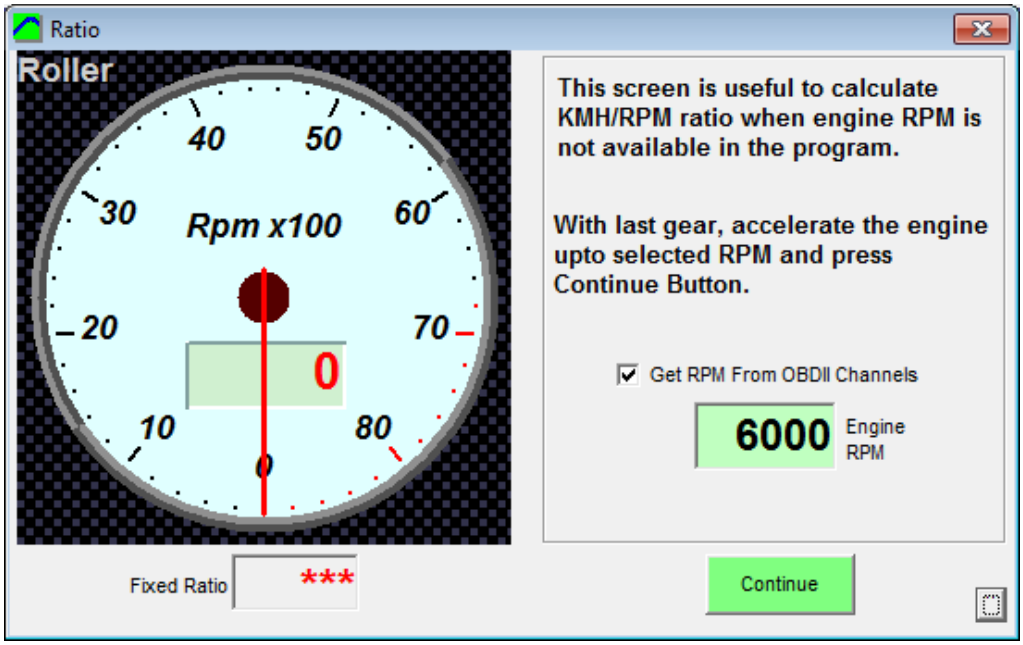
Ratio is a **key** parameter which is used on several processes of Sportdyno, and also on SP5 for speed control:

- It is used to convert Roller Torque to Engine Torque. Due to the gearbox torque conversion, normally torque at roller will be higher than at engine.
- It is used for drawing the Engine RPM axis, and as reference for the torque and power peak values.
- On SP4 and SP5, it is used to calculate an estimation of engine RPM (from roller RPM), since only roller RPM is used for speed control, but all target values are referred to engine speed.



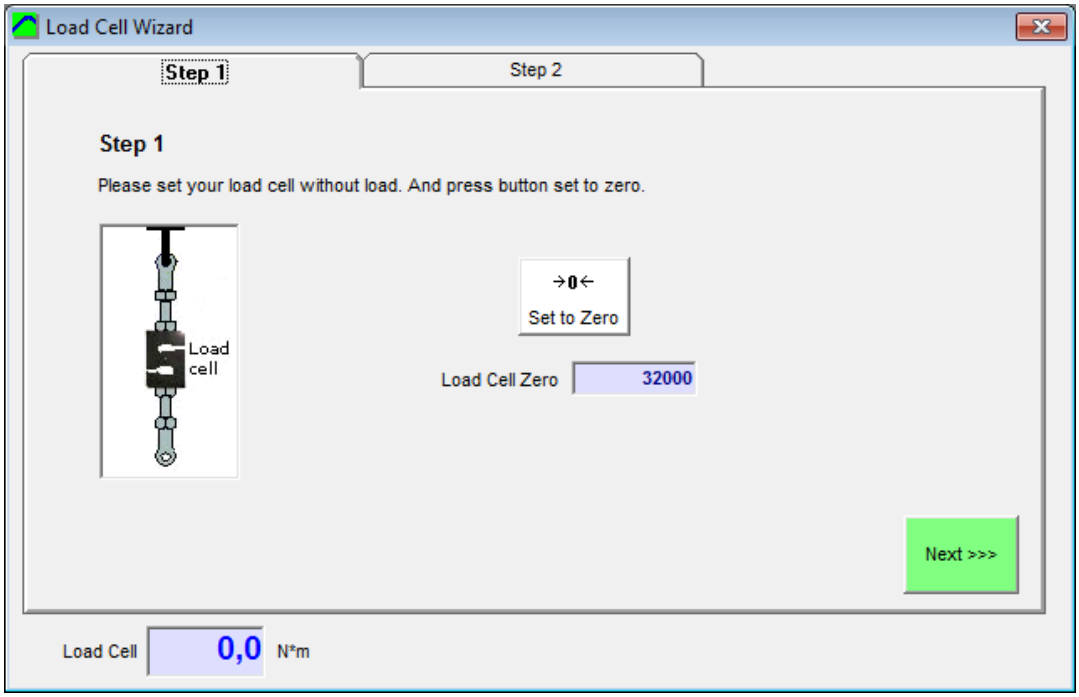
There are three ways to provide ratio to Sportdyno:

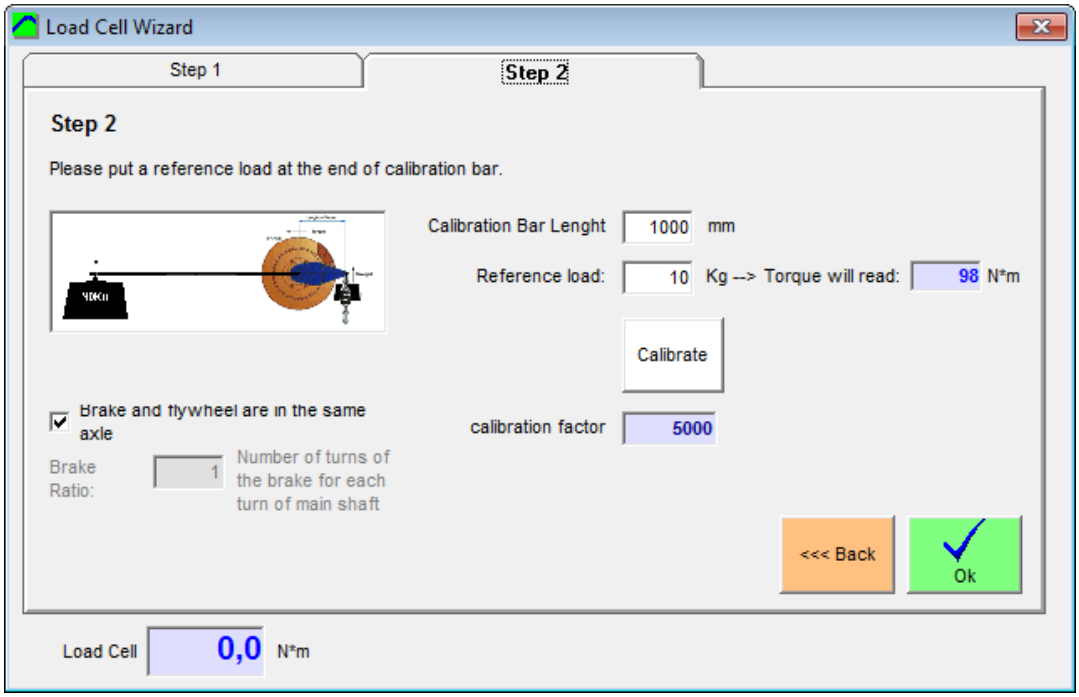
- **Using capacitive or inductive clamp:** Although Engine RPM Channel is not directly used for the three functions described below, Sportdyno will perform an histogram from engine rpm and roller rpm channels to get the Ratio value before starting the test, and (by default) after the test is finished
- **Fixed ratio**: in certain cases when Ratio value is known ratio can be setup directly (for instance engine test bed when there is a fixed transmission from engine to flywheel / brakes)
- **Test Ratio**: this option will open the "Test Ratio" window. Based on the vehicle's Engine RPM gauge this tool will determine the ratio value from Roller channel and the entered value for Engine RPM. The main disadvantage of this method is that normally all vehicle's Engine RPM gauges have an error between 10% and 20%, thus Ratio value will have this error too.
  NOTE: When using **OBDII** Interface Engine RPM can easily be acquired from the vehicle's ECU for the Ratio calculation.



4.3 Load Cell Calibration

Load cell calibration consists of applying a known weight on a calibration arm at the brake. But first of all, the cell has to be “zeroed” when it has no weight. Then the program is able to use the difference from the digital reading between the no-load condition to the loaded condition to perform the calibration.



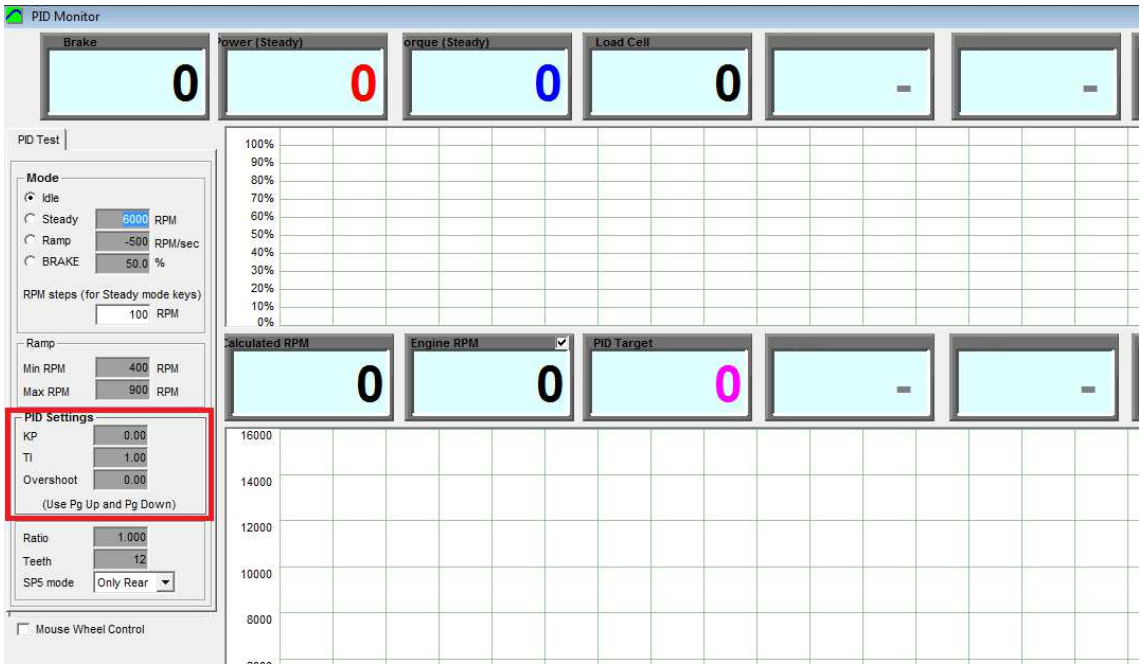


Note: if no calibration arm is available, calibration can be performed directly over the cell arm/lever with the following considerations:

- Calibration arm length is the load cell arm length (distance from brake axle to cell)
- If cell works in pulling mode, then fill the reference load with a negative weight (for instance -20 kg for a 20 kg weight)

4.4 Speed Control Configuration (SP4 and SP5)

P.I.D. coefficients determine the brake response to the difference between the desired speed (target) and the current speed (this difference is called error).
SP5 implements a standard PID, with I constant proportionally to P (Kp) → Ti, this allows changing only Kp constant and SP5 will modify Ki to keep the same dynamic behavior. (Ki = Kp * 1 / Ti)
SP5 does not implement a Kd derivative constant, but it implements a more sophisticated overshoot control.



A good starting point for PID setup is:

Kp = 1 (1 to 2 for motorcycles, or 5 to 10 for car dyno, it may be higher)
Ti = 1 (0.3 to 1.0)
Overshoot = 0

Kp basically controls the speed control reaction time. Control can be made faster increasing Kp, but excessively high values will cause fast oscillations on the system, thus a balance has to be found between speed response and stability
Kp by itself cannot make the speed control to reach the exact target speed, for this reason the integral control (I) is used.
Ti is (normally) modified in a narrow interval (typically 0.5 to 1.5) to get a faster approaching / drift to the target (low values), but fast approaching / drift also cause to decrease the reaction speed.

Overshoot: With high inertia dynos, some overshoot will be present in the control operation, but normally a small overshoot is preferred as it ensures faster control than no overhoot.
Nevertheless, with lightweight dynos overshoot can be excessive and then the Overshoot coefficient has to be used to decrease overshoot to a safer value.

Note: **Power supply version 1.5** or higher is strongly recommended as they provide faster and more accurate response.

Document changes:

V1.1 – Changes due to HW version 2.2:

- 12V pin added to CN3 (pin 8),
- Airspeed pin moved to CN4 (pin 2)
- Servo pin duplicated in CN3 and CN4 (pin 3)

V1.2 – Changes due to errata

- CN7 and CN8 connectors (lambdas) were swapped