FOCUS APPLIED TECHNOLOGIES
DYNAMOMETER SYSTEM
DYNO MODEL HMD
CONTROLLER MODEL DC5

Manual Rev. 2-0516

5kW EDDY CURRENT CHASSIS DYNAMOMETER
WITH CONTROLLER

CONTROLLER FRONT VIEW

Display   Alarm   Set Point Adjust   Dyno Current Switch

Menu/Setup Keys   Throttle Adjust   Mode Switch   Power Switch

CONTROLLER REAR VIEW

Fan   External Transformer Input   Speed Inputs   Analog Inputs   Load Cell Input

Line Power   Breakers   Dyno Current   Engine Ignition   Alarm Inputs   Analog Outputs   Serial Com
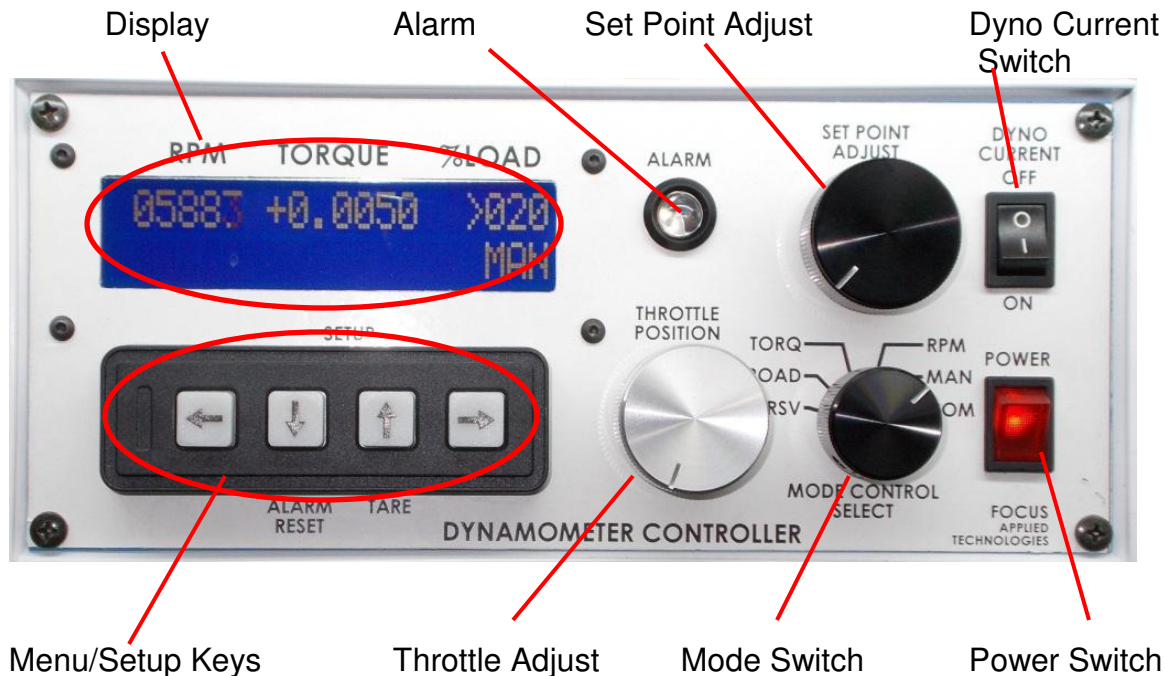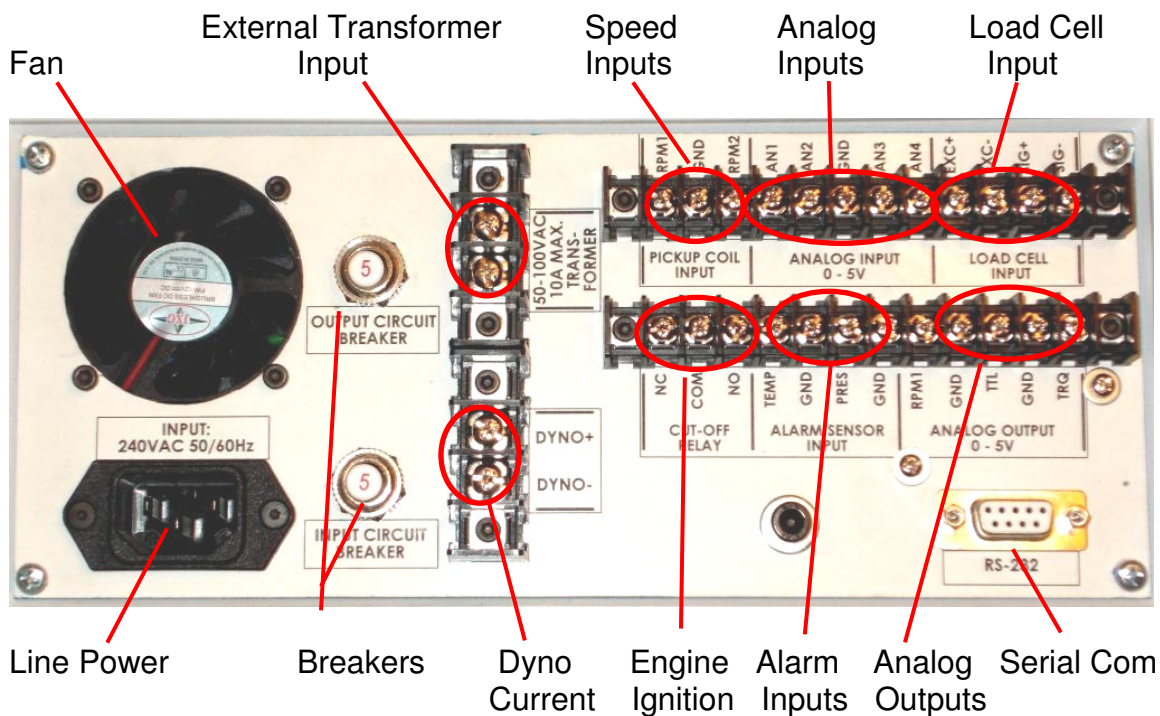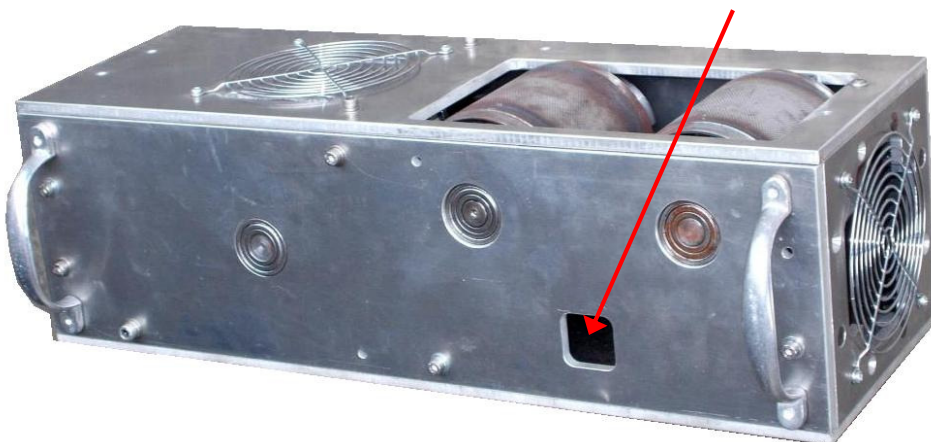
DYNAMOMETER INTERNAL VIEW

Dynamometer   Fan

Main Roller

Idle Roller
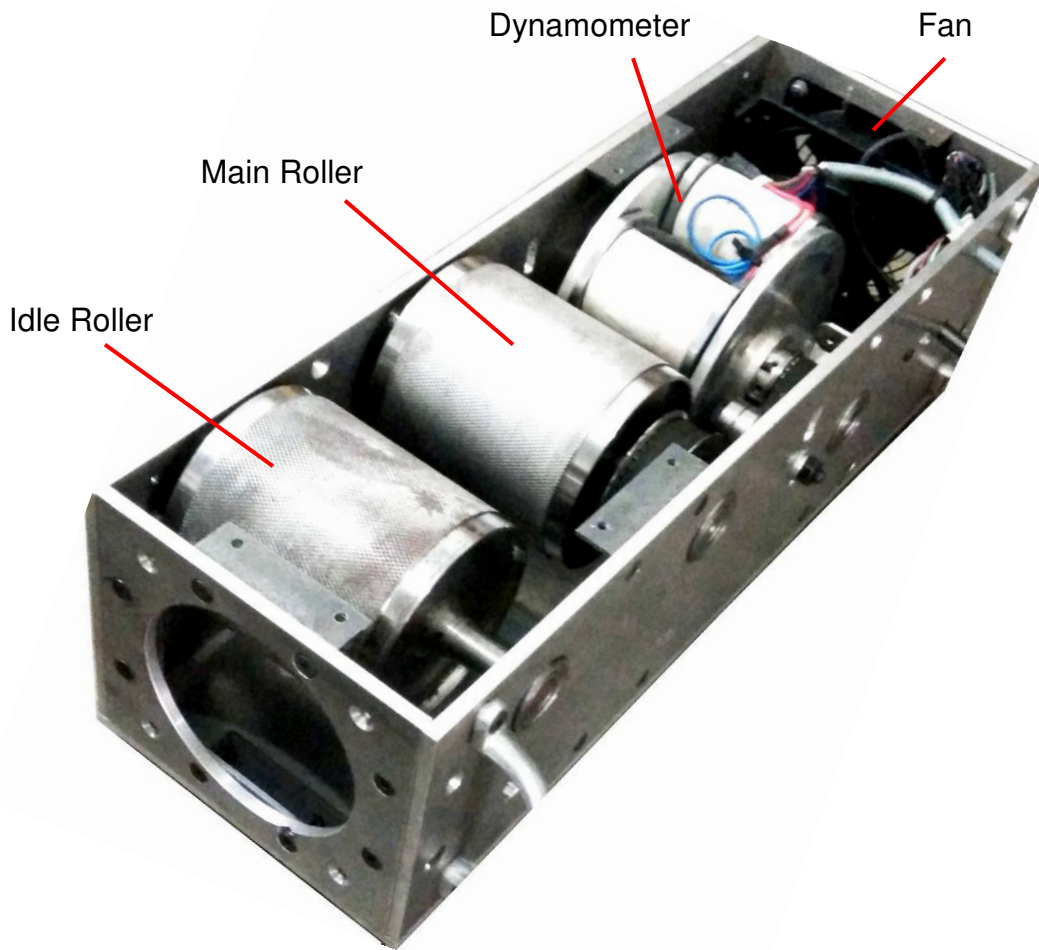
Recommended Vehicle Securing:

Straps should pull down, and slightly back to the securing holes below the rollers

NOTE: block the front wheels and bolt the dyno to the ground if possible.

FEATURES

Dynamometer

The dynamometer is an eddy current chassis dynamometer. Power from the vehicle rotates the main roller, which drives the disks of the dynamometer via a 2:1 toothed belt and pulley system. The dynamometers axial magnetic field is controlled by the dynamometer current. More current gives a stronger stator magnetic field, inducing more eddy current in the rotating disks. The resulting magnetic field produced in the disks opposes the direction of motion, creating drag on the disks, and a torque on the stator which is measured by a load cell. Power from the vehicle is dissipated as heat in the spinning disks. This dynamometer features low-friction bearings, and the bearing friction can be calibrated out, resulting in a highly accurate, low cost robust dynamometer.

Dynamometer Controller

This dynamometer controller allows the user to control the dynamometer in several different modes: Manual, Speed, Torque, Road Load (RPM^2) and Computer (remote) mode. Which of these modes to use depends on the specifics of your testing. For simple loading of a vehicle (ie. adding or reducing the load) the easiest mode is the Manual Control mode. For constant speed operation (Torque will vary) use the Speed Control mode. Road Load mode is commonly used to simulate the aerodynamic load a vehicle when operated on the road. Note that inertia/mass is not matched unless this dynamometer specifically has an inertial load, however vehicle mass effects can be simulated in the Road Load mode. Computer control mode is used for automated testing, often in conjunction with the throttle control, which can also be operated remotely from the computer.

Computer Communications

A computer can be connected to the dynamometer controller for logging data from the Dynamometer Controller, Fuel Scale and Data Acquisition systems via Serial Ports. If serial ports are unavailable then a USB-Serial Port converter may be used. Serial port communications are via RS232: 9600 baud, No parity, 1 Stop bit. The cable should be a "straight through" cable connecting pins 2, 3, and 5 at both ends. In Verbose mode the controller automatically sends data out in the format shown below at approximately 4Hz. During power on the controller sends out a "Power On" message with the firmware code. Data can be logged from various serial communications programs including Hyperterminal. Various controller parameters can be modified from the computer interface, and data can be logged by the computer as well. In Verbose mode the controller will automatically output data to the serial port every 250ms. When the control is NOT in Verbose mode sending the character "A" will cause the controller to respond with the data.

In general the computer data is output in the following format:

ZSSSS1_SSSS2_TT.TTT_LLL_Mode_SP_TTL_Alarm_A1_A2_A3_A4 [CR]

Where:
S is speed in RPM (S1 is rpm1, displayed on the front panel, S2 is rpm2 which is not displayed on the front panel)
T it torque in Nm
L is load in %

Mode is the mode:

      NM for front panel Manual mode, CM for Computer Manual
      NS for front panel Speed mode,   CS for Computer Speed
      NT for front panel Torque mode, CT for Computer Torque
      NR for front panel Road Load mode,   CR for Computer Road Load

SP is the set point
TTL is the throttle position (0-1023 is 0 to Wide Open)
Alarm is 0 for no alarm, and 1 for alarm
A1 .. A4 is the Analog input in 0-1024 (ie. 10 bit) 5V resolution.
The separator between the fields is a space character

For example:

Z2510 6500 12.345 20 NS 2500 53 0 123 345 678 1023

Speed is 2510 RPM
Speed 2 is 6500 rpm
Torque is 12.345Nm
Load is 20%
Mode is Front Panel, Speed Mode
Set Point is 2500
Throttle is 53
No Alarm state present
Analog Input 1 is 0.601V   (ie. 5*123/1023)
Analog Input 2 is 1.686V
Analog Input 3 is 3.314V
Analog Input 4 is 5.00V

Data Acquisition System

      This dynamometer controller includes a basic Data Acquisition System (DAQ). This system is for reading signals from various sensors commonly used in engine testing such as Thermocouples, Pressure Sensors, Voltages and etc. Several channels are available for the use, and are logged along with the standard controller data (eg. Speed, Torque, %Load, Control Mode, Alarm Status). All of these sensors can be read by the computer data logging software for display and recording.

NOTE: Analog input voltages are limited to 0 to 5V. If measuring voltage above 5V you must use a voltage divider to reduce the voltage to below 5V max.

Fuel Scale

      Some test systems are equipped with a fuel scale. This digital gravimetric fuel scale measures fuel weight as it is consumed by the engine under test. The data is fed to the computer via serial (RS-232) communications link, allowing seamless integration with our dynamometer and DAQ systems. The weight of fuel is measured as a function of time allowing direct measurements of fuel consumption, and calculation of Break Specific Fuel Consumption (BSFC), and Fuel Mass Flow rate, for calculation of actual Air Fuel Ration (AFR) when combined with an air flow sensor.
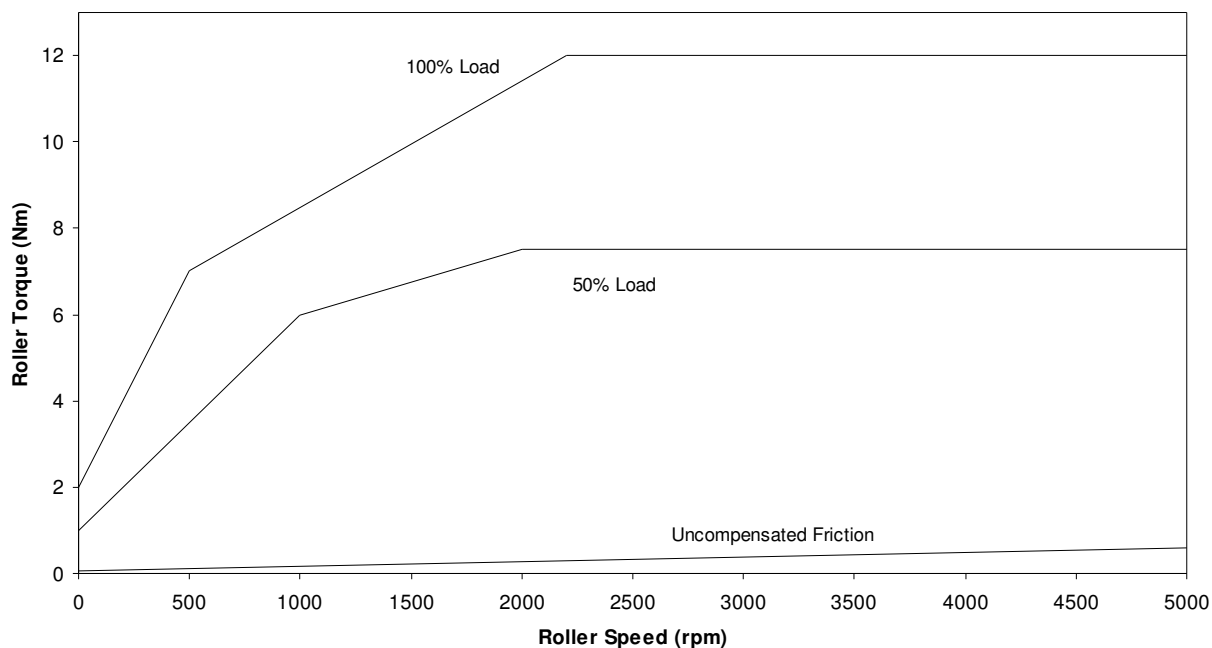
Dynamometer Operating Range

The dynamometer is designed to operate at up to 10000 rpm, giving a roller speed of 5000rpm. This corresponds to a vehicle speed of 95kph, or about 60mph. Friction of the bearings inside the dynamometer are measured, and displayed along with the dyno's induced torque. The rollers are supported by bearings which result in unmeasured torque losses. Additionally there are bearings on the dynamometers main shaft which are not measured. To properly compensate for these unmeasured frictional losses the following Torque Friction Correction equation is used:

Compensated Torque = Measured Torque + 1 Nm (0.08+ RPM/9600)

For example if you are measuring 6Nm of torque at 3000rpm, the compensated torque is 6Nm plus 1Nm x (0.08+3000/9600) or about 6.4Nm total. If the DynoParameters file is set up correctly, the Torque displayed on the computer will be correct.
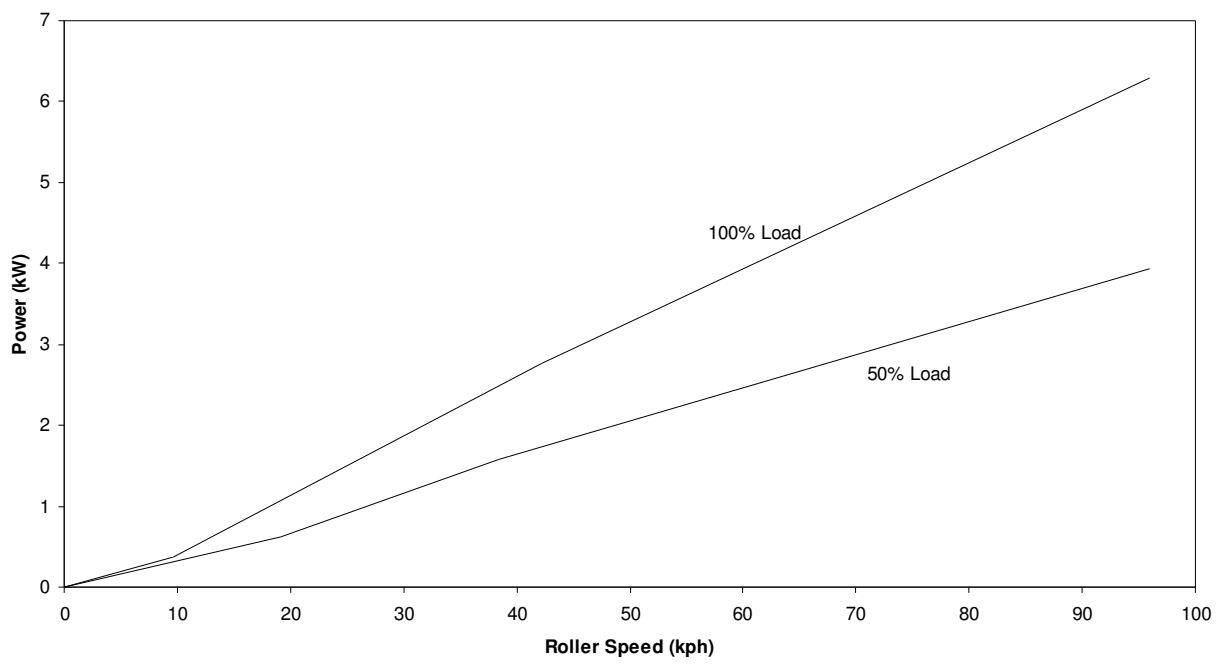
The maximum torque rating of the dynamometer is approximately 12Nm. This gives a maximum mechanical power of approximately 6kW at 5000rpm. Tire losses on the on the roller are approximately 10%, giving a maximum wheel torque of over 6.5kW. The area of safe operation is shown below.

NOTE: Dynamometer friction is compensated for in the "Total Torque" number on the dynamometer logging display, but tire losses are NOT. To include these losses multiply torque by 110%. Power will also be increased by this same factor.

Torque is limited by the available voltage from the dyno at low speeds. At higher speeds, the torque is relatively constant as the dynamometer operates in a current (torque) limited mode. The roller speed should be limited to 5000rpm to avoid damage to the dynamometer. The lower limit of torque is the total friction. The safe area of operation is anywhere between the frictional curve and the 100% load line. For reference a 50% load line has been given.

The maximum power curve is given below. The dynamometer can extract power in excess of 6kW at 95 kph.

SPECIFICATIONS

DIMENSIONS

LxWxH:	500 x 160 x 170 mm
Weight:	Approximately 18kg (Dynamometer unit)

POWER IN

Voltage:	120 VAC +/- 10%, or 220+/- 10%
Frequency:	60Hz 50Hz
Current Draw:	4A max

CONTROLLER OUTPUT

Resistance:	10 ohms minimum
Power:	200W maximum
Voltage:	50V nominal
Current:	3A nominal

DYNAMOMETER

Mechanical Power:	6,000W nominal maximum
Roller Diameter:	101mm
Gear Ratio:	2:1

INPUTS

Speed:	Hall Effect type input on Dyno side
	8 pulse per revolution (4 teeth on dyno x 2:1)
	5V Zero-peak
	5000 rpm maximum at main roller
	95kph (60mph) maximum linear speed
Load Cell:	20Nm maximum Loading
	200 to 500 ohm
	4-wire Wheatstone bridge
	5 or 10V excitation

SERIAL COMMUNICATIONS

Baud, Bits, Parity, Stop:	9600, 8, N, 1

ENVIRONMENT

Temperature:	10 to 40°C Operational
	0 to 50°C Non-Operational
Humidity:	5 to 90% Non-condensing
Shock/Vibe:	<10g

DYNAMOMETER STARTUP PROCEDURE

This controller is equipped with several safety features to avoid damage to the dynamometer and engine. Theses must be correctly wired to insure safe operation. This section describes their setup and use.

Dynamometer Startup Procedure

1. VMI: Visually inspect all components of the dynamometer system, engine and fueling system for make sure there are no missing or broken components, leaks or loose items which may cause damage.
2. Turn Computer ON
3. Turn Dynamometer Current to the OFF position
4. Switch the Mode selector switch to MANUAL mode
5. Set the Set Point Adjust to 0%
6. Turn the Dynamometer Controller and Power Unit ON
7. TARE the load cell (this may be repeated after unit has warmed up for best results)
8. Set the Throttle Set Point to IDLE

Fuel Scale Startup Procedure

1. Switch ON the Fuel Scale
2. Zero the Fuel Scale Load
3. Load the Fuel tank with fuel
4. Place the fuel tank on the scale
5. Confirm that the scale is not overloaded

Engine Startup Procedure

1. Check the Engine Oil and Coolant levels
2. Check Vehicle – Insure it is strapped securely to the dynamometer
3. Place the engine in Neutral Gear
4. Power ON the Cooling System (Fan or water pump)
5. Power on the exhaust system
6. Open the Fuel Valve
7. Turn ON the Engine Ignition
8. Place Throttle to the START position (IDLE)
9. Start the engine and IDLE

Vehicle Testing Procedure

1. Place engine in required gear
2. Switch Dyno Current ON
3. Switch Controller to appropriate Mode
4. Adjust Set Point to desired set point
5. Open Throttle to Desired Operating Condition

6. Commence Measurements, adjusting either Set Point of Throttle as required

Shut Down Procedure

1. Reduce Throttle to Idle
2. Save all data on the computer
3. Place Dynamometer in Manual Mode
4. Reduce Dynamometer load to 0%
5. Switch Dyno Current OFF
6. Place the Engine in Neutral Gear
7. Allow the engine some time to cool at IDLE if hot
8. Once the engine has cooled Continue:
9. Shut OFF the Engine Ignition
10. Turn OFF the Fuel Valve
11. Turn OFF the cooling system (Fan of Pump)
12. Turn OFF Exhaust fan
13. Stop the Computer Data Acquisition Program
14. Shut OFF The Fuel Scale
15. Shut OFF The Dynamometer and Power Supply

DYNAMOMETER CONTROLLER

Modes of Control

This dynamometer controller allows the user to control the dynamometer in several different modes: Manual, Speed, Torque, Road (RPM²) and Computer Control mode. Which of these modes to use depends on the specifics of your engine testing. For simple loading of an engine (ie. adding or reducing the load) the easiest mode is the Manual Control mode. For constant speed operation (Torque will vary) use the Speed Control mode. For automated testing, use the COMputer controlled mode, which also allows control of the Throttle setting. In all operating modes the **TARE** key zeros out the torque reading, and **Alarm Reset** resets the alarm state, assuming the cause of the alarm condition has been cleared.

Manual Control

In Manual Control mode the Set Point Adjust knob directly controls the current going to the dynamometer. For a given speed, the load will be directly proportional to the knob setting: 0% load at one end, 100% load at the other end.

The most common engine testing is done using manual mode control. For a torque/power curve of the engine, the engine can be started and throttled up to "redline" (ie. the maximum rated speed). Dyno load is increased as the throttle is opened to keep the engine just at redline speed. Once the throttle is fully open, the torque and speed are recorded. Subsequently the load in increased in small steps, causing the engine speed to decrease. At each new speed the torque and speed are again recorded. Repeating this in steps of 500 rpm allows the wide open throttle (WOT) torque curve to be determined.

NOTE: Engines operating at Wide Open Throttle can generate a lot of heat. Make sure you supply the engine or motor with sufficient cooling air.

Speed Control

In Speed control mode the Set Point Adjust knob sets the desired speed. If the engine is operating above the set speed, the controller will increase the current to the dynamometer, increasing the load on the engine, and slowing it down to the set speed. If the engine is incapable of reaching the set speed at a given throttle, the engine will operate at a speed below the set point, and the dynamometer will be completely unloaded. For best results the PID gains must be carefully adjusted.

Torque Control

In Torque control mode the Set Point Adjust knob sets the desired Torque. If the dyno is operating below the set torque, the controller will increase the current to the dynamometer, increasing the load on the engine, and slowing it down, while the torque increases to the set point. If the engine is incapable of reaching the set torque at a given throttle, the dynamometer will continue

to add load until the engine stalls, the clutch slips, or maximum load is attained. If the dyno torque is above the set point, then the load will be reduced, dropping the torque, and increasing the speed.

Road Load Control

In Road Load control mode the load is varied as a function of speed to mimic aerodynamic loading of a vehicle. Load is increased proportional to the square of the speed, with no load at zero speed. In this mode the set point adjustment know controls the proportionality constant. A larger constant is used for physically larger vehicles, while a smaller constant is used for smaller, or more aerodynamic vehicles. A good way to calibrate the constant is to operate the vehicle at a known throttle/speed combination. If the vehicle speed is higher than the desired operating point the constant can be increased, and if the speed is lower, the constant should be decreased. This calibration should be performed in the mid-point of the desired test speed range. Once the constant is established for a given vehicle, it should always be re-used for that particular model.

Computer Control

In Computer control mode the operating control mode and set point and throttle position are received from the computer via the serial port. The command sequence to be sent from the computer is as follows:

CSSSSS
Where:
C is a character indicating the control mode:
     M for Manual
     S for Speed
     T for Torque
     R for Road Load
SSSSS is the appropriate set point

For Example here are several valid mode/setpoint commands:

M0128   Manually Sets Load to 100*128/1024 or 25%
S12250   Sets Speed control mode to 12250 rpm
T01234   Set Torque control mode to 12.34Nm
R0512   Set Road Load with factor of 50% (512/1023)

NOTE: the controller needs to receive the correct number of digits, so "preceding" zeros must be sent. M and R modes require 4 digits (0000-1023) and S and T modes require 5 (00000-65350).

For throttle Position control send the following sequence:

PXXXX
Where XXXX is the desired load (0 to 1023)

For Example the following sequence sets the throttle output voltage to 50% (ie. 2.5V):
T0512

NOTE: the controller needs to receive the correct number of digits, so "preceding" zeros must be sent. For P mode 4 digits are required (0000-1023).

Internal Strain Gage Amplifier

This dynamometer controller features an internal strain gage amplifier. This amplifier can be connected to any standard Wheatstone bridge configuration 4-wire strain gage load cell. The amplifier may be bypassed if the load cell does not require further amplification.

Internal Dynamometer Power Supply

This dynamometer controller features an internal power supply providing DC current to the dynamometer coils. Make sure not to exceed the power supply ratings. In general the dynamometer coil resistance should be more than 10 ohms. When operating loads requiring more power, it will be necessary to provide an external power switching device (ie. transistor), which may be triggered from the controller's dynamometer output by running it through an appropriate voltage divider.

Serial Port Data Logging

Along with the controller a "serial port data logging" program is also supplied. This program communicates from any PC via the serial port directly to the dynamometer controller and can display and record the mode specific set point (ie. set speed or torque), dynamometer speed, torque, and dynamometer load (duty cycle). It may require the installation of Agilent VEE driver software, which can be downloaded for free from the appropriate Agilent website. The simple serial port communications protocol can also be reproduced in user defined programs for customization.

The Dynamometer controller can be set up to "broadcast" its data automatically by turning the "Verbose" mode ON. This can be done from the front panel menu in manual mode. When verbose mode is OFF the controller will only send out data in response to a received character "A". This is done on some systems to help synchronize data acquisition. Make sure not to issue the A command to the controller more than once very 250ms.

Controller Setup

From the main menu you can access the setup menus using the **right** or **left** arrow keys. Different menus are available for the different modes, as selected by the mode switch. To adjust any of the parameters use the **Up** and **Down** arrow keys. To permanently save changes you make to the configuration use the Up arrow to change the **Save Config?** Value to **YES** then hit the **right** arrow key to exit the menu.

In Manual mode you can select the over speed and torque limits, and the "Pulses Pre Revolution" for the RPM1 and RPM2 speed signals. If a target wheel has 30 teeth, then the appropriate PPR would be 30. Finally in Manual mode you can set the appropriate position for the decimal in the torque display.
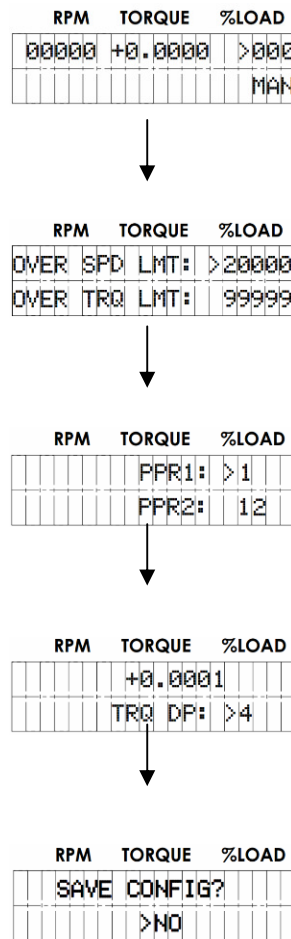
In Speed mode you can adjust the Speed Maximum Set Point, and the Proportional, Integral and Differential gain values for the Speed PID Control. For extended PID resolution denominator factors for P, I and D are also provided. If you want finer resolution, and lower gain on a given factor, increase the appropriate factor.

In Torque mode you again have a the Torque Maximum Set Point and the Proportional, Integral and Differential gain values for the Torque PID Control. For extended PID resolution denominator factors for P, I and D are also provided. If you want finer resolution, and lower gain on a given factor, increase the appropriate factor.
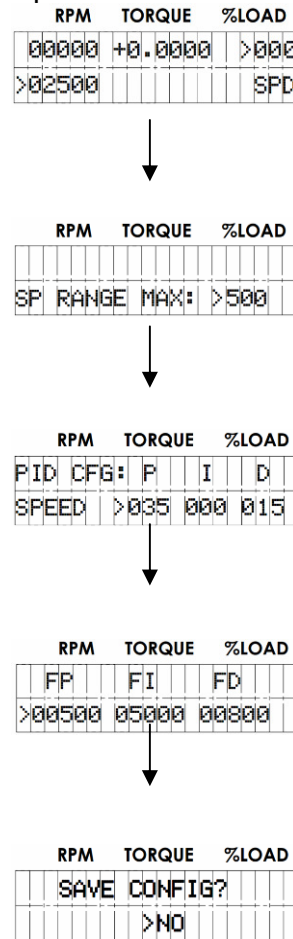
Controller Configuration Menu Map

Set the Mode Select Switch to get access to the various menus. Use the **Right/Left** arrows to page through the menu. Use the **Up**/**Down** arrow keys to change the individual values. To save the configuration use the **Up** arrow key to change **NO** to **YES** at the **Save Config?** screen.
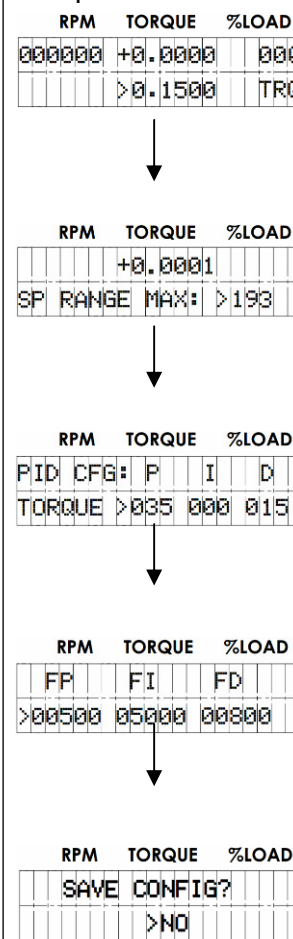
Manual Mode

RPM	TORQUE	%LOAD
00000	+0.0000	>000
		MAN

↓

RPM	TORQUE	%LOAD
OVER SPD LMT:	>20000	
OVER TRQ LMT:	99999	

↓

RPM	TORQUE	%LOAD
	PPR1: >1	
	PPR2: 12	

↓

RPM	TORQUE	%LOAD
	+0.0001	
	TRQ DP: >4	

↓

RPM	TORQUE	%LOAD
SAVE CONFIG?		
	>NO	

Speed Mode

RPM	TORQUE	%LOAD
00000	+0.0000	>000
>02500		SPD

↓

RPM	TORQUE	%LOAD
SP RANGE MAX:	>500	

↓

RPM	TORQUE	%LOAD
PID CFG:	P I D	
SPEED	>035 000 015	

↓

RPM	TORQUE	%LOAD
FP	FI FD	
>00500	05000 00800	

↓

RPM	TORQUE	%LOAD
SAVE CONFIG?		
	>NO	

Torque Mode

RPM	TORQUE	%LOAD
000000	+0.0000	000
	>0.1500	TRQ

↓

RPM	TORQUE	%LOAD
	+0.0001	
SP RANGE MAX:	>193	

↓

RPM	TORQUE	%LOAD
PID CFG:	P I D	
TORQUE	>035 000 015	

↓

RPM	TORQUE	%LOAD
FP	FI FD	
>00500	05000 00800	

↓

| RPM	TORQUE	%LOAD
SAVE CONFIG?		
	>NO	

CALIBRATION AND ADJUSTMENTS

Speed Calibration and Adjustment

Speed is determined from the frequency of teeth passing the speed pickup. As such the only calibration required is setting the proper number of teeth on the speed target wheel. The standard speed target wheel has 4 teeth and is mounted on the Dynamometer (as shown below), thus the controller should be set up for **8 pulses per revolution (PPR)** to give the appropriate roller speed. This can be set from the front panel by hitting the right arrow in Speed mode, and following the prompts on the screen.

To properly read the teeth is it important that the speed pickup be clean, and in close proximity to the target wheel. The gap between the speed pickup tip and the target wheel should be approximately 1.5mm. The acceptable range is 1mm to 2mm.

Gap: 1mm to 2mm
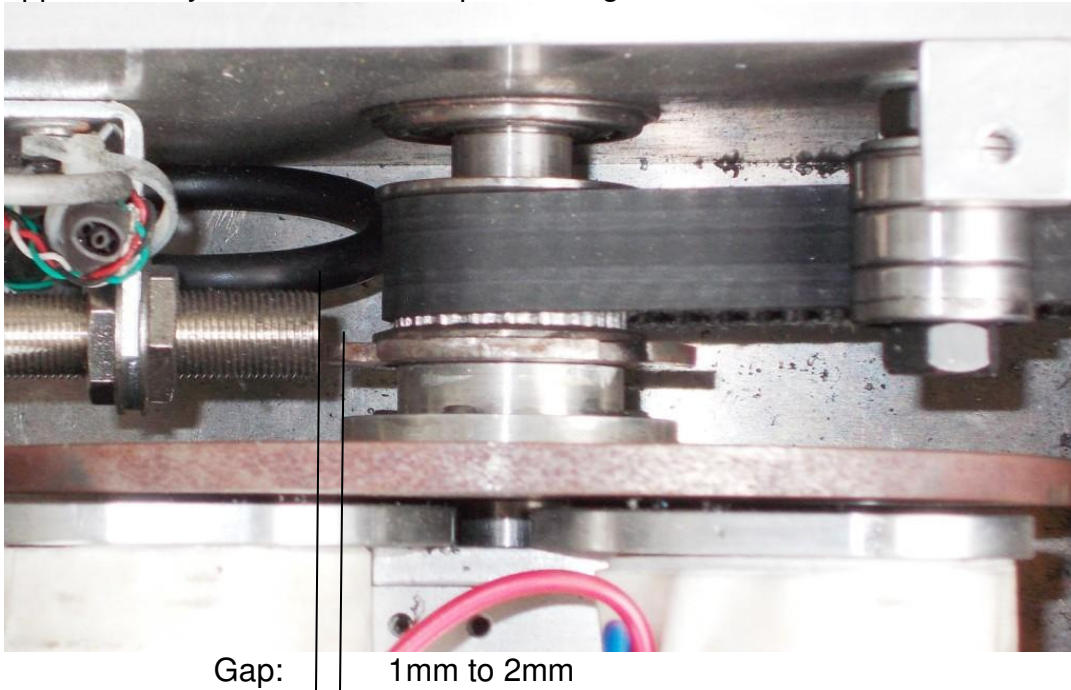
To adjust the gap, loosen the large nuts securing the sensor to the holding bracket, adjust the gap, and re-tighten the nuts. Do not over tighten as this can destroy the sensor.

Torque Calibration

A calibration weight "platform" is provided with the dynamometer. This needs to be screwed into the load cell as shown below to calibrate the system. First, power on the dynamometer controller and allow it to warm up for 15 minutes. Load the dynamometer by pushing down lightly on the platform, and release. Zero the torque reading by hitting the **TARE** button. A standard calibration weight weighs 1 to 10kg and the radius of the mounting hole is 0.051m from the center of rotation of the dynamometer. As the torque reading is the MAIN ROLLER torque, ie. twice that of the dynamometer torque, thus the torque resulting from a mass M is at the main rollers is simply M:

**Torque = M x 9.81 x 0.051 x 2 = M (Nm)**

Where: M is the weight of the mass in kg
          9.81 is standard gravitational acceleration

0.051 is the radius of the weights in meters
2 is the gearing ratio to the main roller

For a1kg mass this should give a reading of **1.0Nm**. If the front panel torque reading is different from this amount, then the calibration factor must be adjusted. To do this put the mode selector switch in TORQUE mode and go to the front panel menu by hitting the right arrow, and adjust the torque calibration factor up or down as appropriate. Remove the weight, re-zero torque and recheck calibration when finished.

This view shows the Calibration Weight Platform screwed into the internal Load Cell for calibration.
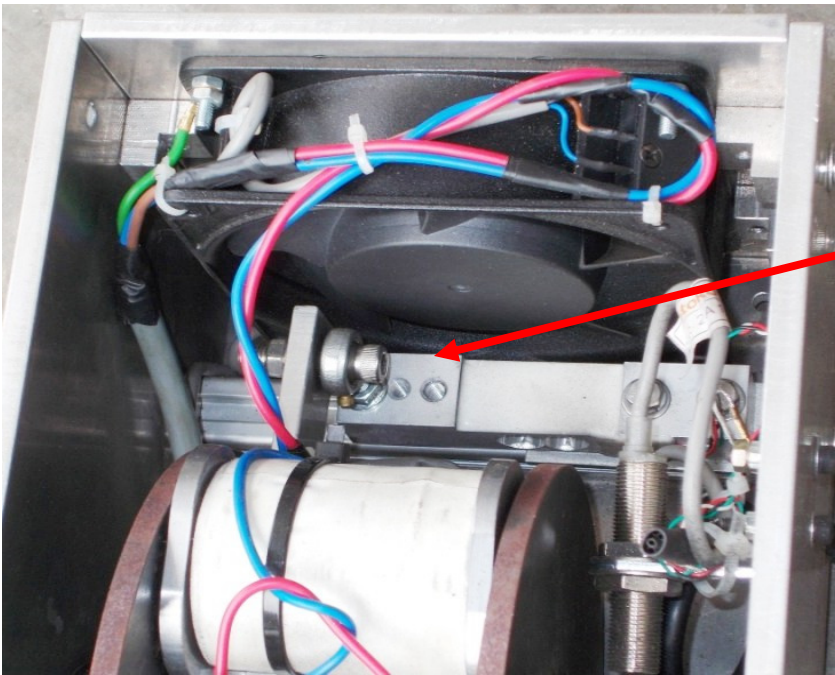
Calibration weight platform screws in to this threaded hole accessible from a hole in the top cover

MAINTENANCE GUIDE

This chassis dynamometer is designed to require relatively little maintenance once properly setup, however there still are a few items that require periodic checking and maintenance. The roller bearings require oiling annually, the belts require periodic tensioning, and may eventually require replacement. The unit may also require cleaning to remove any debris which has accumulated inside the dynamometer housing. Each of these is described separately below.

Oiling Roller Bearings

There are six roller bearings, one at each end of the rollers and one at each end of the dyno (circled in foto below). The bearings should receive a drop or two of light oil annually. This should be done once each year, or every 300 hours of operation.
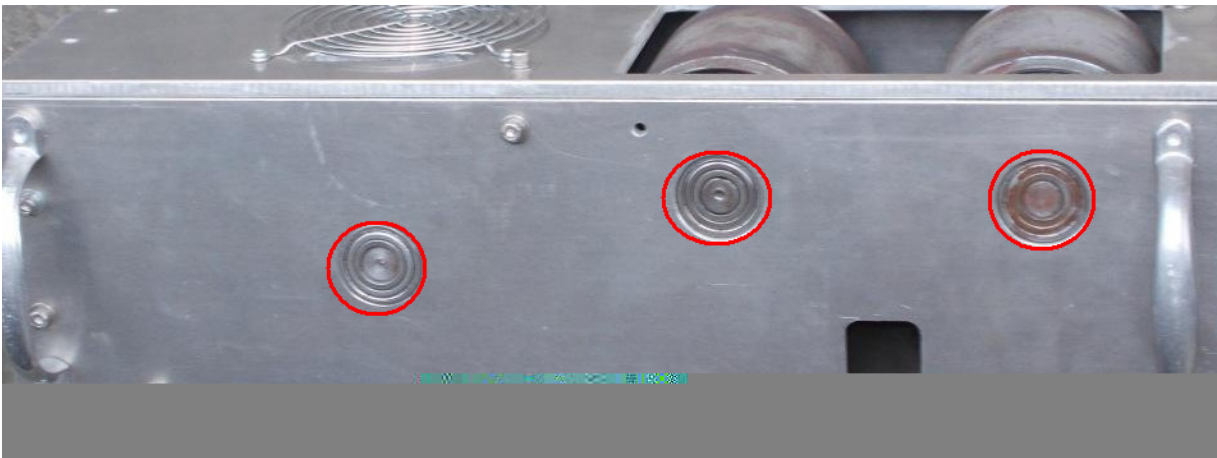

Cleaning

To clean the unit, simply remove the top cover, and sweep, vacuum or blow out the debris which has accumulated inside. The fan blades can be checked and cleaned, and the belt integrity can be checked, and re-tensioned, or replaced as required.

Tensioning Belt

As the dynamometer is used the belt will tend to stretch and the belt and sprockets may wear slightly. As this happens the belt will slacken, and result in increased backlash between the main roller and the dynamometer. To reduce this backlash the belts must be properly tensioned.

To tension the belt simply loosen the tensioner bearing bolt, push down slightly to take up the slack, as shown by the arrow below, and re-tighten the tensioner bearing bolt. As the belt is "toothed" it does not require a great deal of tension, simply insure that it is not slack. The belt should be tensioned so that the belt can be compressed by no more than 2mm at a point half way between the sprockets when squeezed with your fingers.

EXTERNAL WIRING DIAGRAM
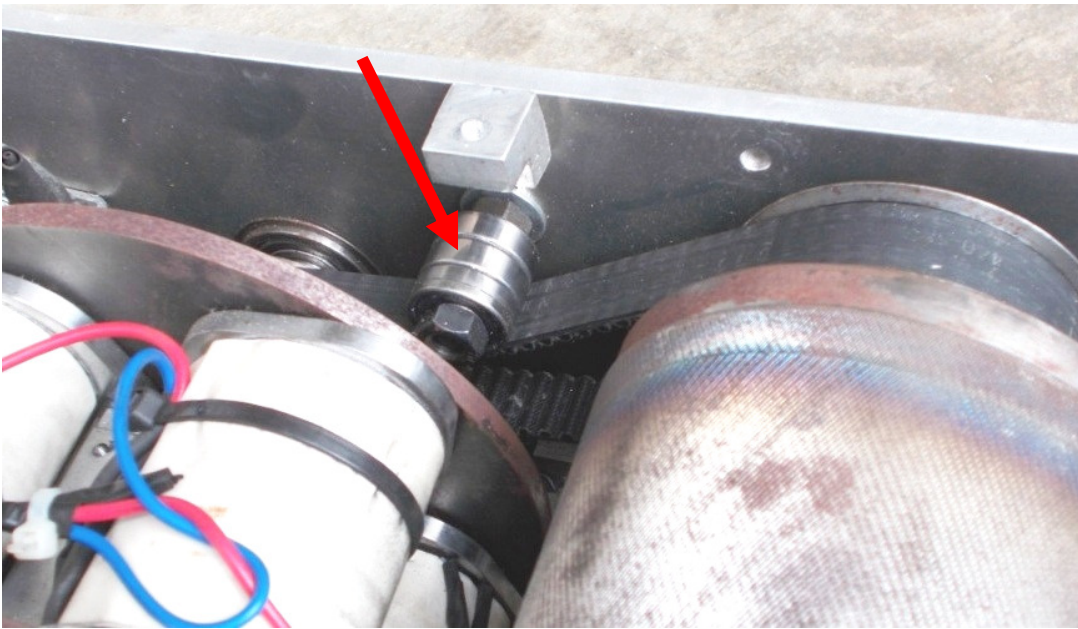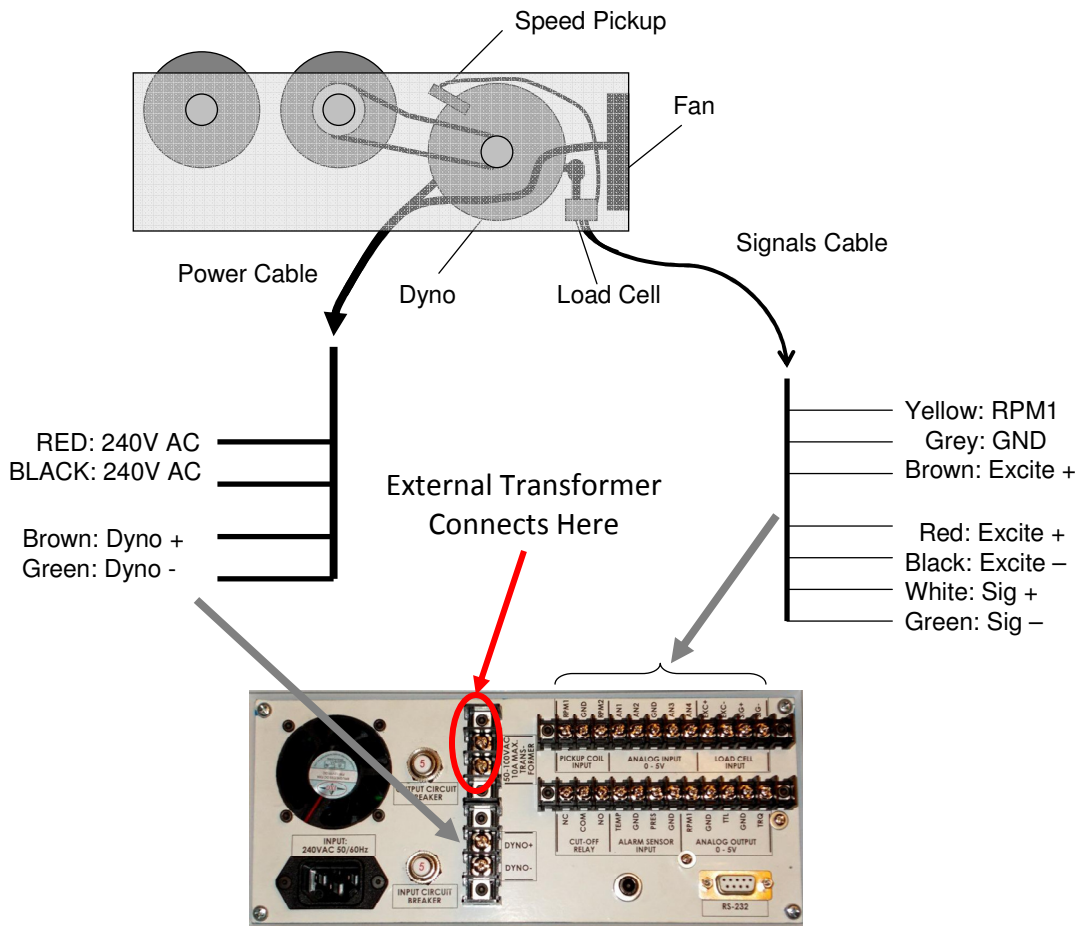
The Controller should be is powered from a clean AC line power source.

The Dynamometer +/- power lines are connected to the "Dyno In" lines on the dynamometer with power cables (10A capable). Insure appropriate gage wires are used. The fan's power is provided via the same harness, and should be connected to 204V AC (120V AC on 120V systems). If an external transformer is used, connect it to the appropriate mounting locations on the back of the dynamometer controller.

WARNING: Both the Dyno +/- control lines may have high voltages on them and can cause shocks or electrocution if handled improperly! Always use appropriate cautions when using/installing the dynamometer.

The speed pickup is connected to the appropriate inputs via a shielded co-axial cable. This signal is polar and should be switch from about 0V to 5V DC when the main roller is rotated.

The load cell amplifier is connected to the appropriate connections on the dyno controller, typically: RED = Excite+, BLACK = Excite -, WHITE= Sig+, GREEN = SIG-

Serial port communications are via RS232: 9600 baud, No parity, 1 Stop bit. The cable should be a "straight through" cable connecting pins 2, 3, and 5 at both ends. The data from the controller will be decimal coded ACSII number for the speed, torque and other data separated by a space and terminated by a linefeed/carriage return. The controller will send data 4 times a second in Verbose mode, or respond to a "A" character ping.

DYNO MONITOR PROGRAM
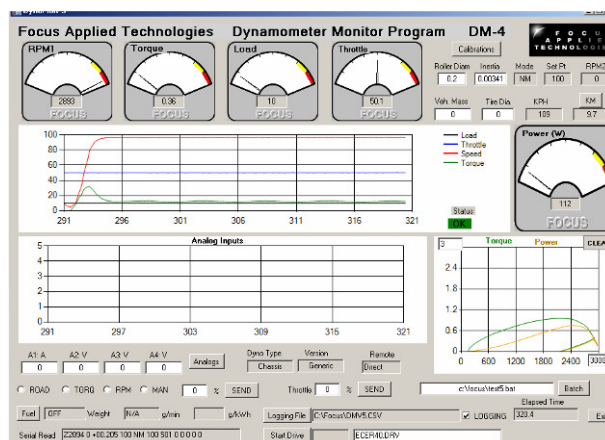
The Dyno Monitor software is supplied with out Gen-5 Dynamometer Controllers for display, data logging and Control of the Dynamometer. This document details the usage of the Dyno Monitor program.
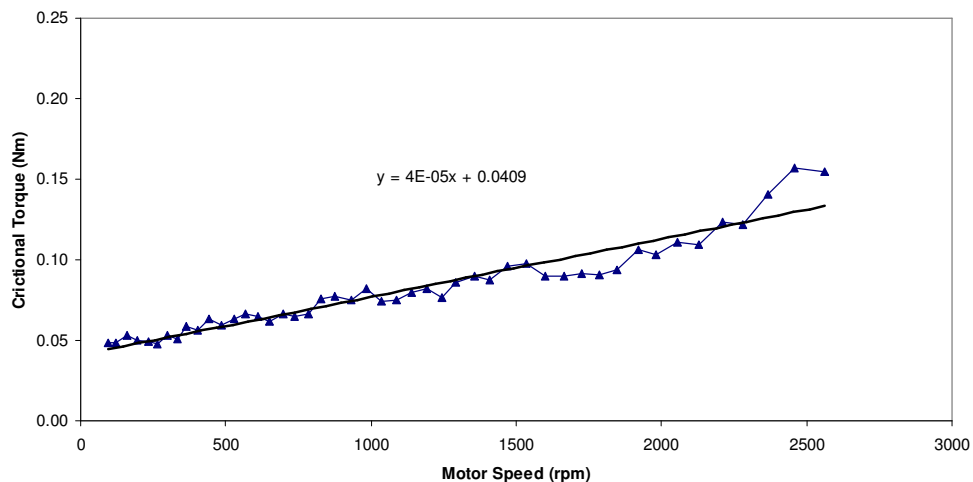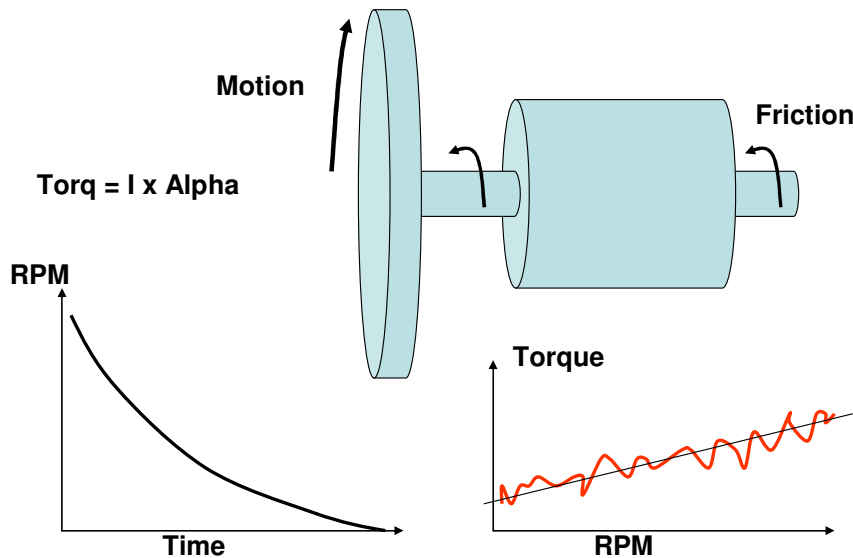
To begin with the Dyno Monitor software should be "unzipped" and loaded into the **C:\Program Files\Focus** folder. If an older version exists, it should be Uninstalled first (From START menu, go to Control Panel, and then Add or Remove Programs, Click "DynoMonVx" and Uninstall).

Additionally a calibrations file **C:\Focus\DynoCal.CSV** should exist. If the folder does not exist, then create it. The Dyno Calibrations file contains important calibration factors relating to your dynamometer, and these should be recorded somewhere safe for reference (eg. in a notebook, or sticker on the dyno, or in a backup file for example DynoCal.Bak). If this file does not exist, it will be created, and can be modified by hand, or from the DynoMonitor program. As a "CSV" (Comma Separated Variables) it can be conveniently opened in Excell or other spreadsheet, and saved (make sure to save as a CSV format). Below is a typical DynoCal file:

Focus Applied Technologies Dynamometer		
Calibration File	DC5	
Version	Default	
Mass		120
Wheel Diameter		0.4
Pulses per Rev		20
RPMPV		0
MPSPV		0
Torque Offset		0
Torque Factor		1
Frict Offset		0
Frict Factor		0
Last Cal	Not Calibrated.	
Dyno Type	Unknown	
Roller Diam		0.3
Inertia		0
Controller Com Port		1
Fuel Scale Com Port		0
Emissions Com Port		0

AFR	3
V	1
V	1
V	1
Analog Offset 1	8.5
Analog Offset 2	0
Analog Offset 3	0
Analog Offset 4	0
T-Graph Max X	3000
T-Graph Max Y	20
Batch File	
Drive Cycle	ECER40.DRV
Temp	25
Press	1000
RH	50
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0
Spare	0

The first 2 lines are headers, and do not effect operation of the DynoMonitor program.

Mass and Wheel Diameter are sometimes used on Chassis Dynamometers. The Pulses Per Revolution relates to the PPR in the dyno controller. It is not necessary to set this in the Dyno Monitor software in most cases. RPMPV and MPSPV are also only used in some systems.

Torque offset and Torque Factor can be used to modify the torque coming from the Dyno Controller. For example if you want to display different units on the screen of the computer (and save to a file) you can assign a torque offset (ie. constant) and Factor (ie. to be multiplied by the read torque) before display. Typically these are 0 and 1 respectively to display the same units as the Dyno Controller (ie. Nm).

The Friction Offset (in Nm) and Factor (in Nm/rpm) are used to compensate for any frictional loads which are unmeasured by the dynamometer. This is often the case in chassis dynamometers where the rollers and Dyno may have 4 or more large bearings applying friction to the roller which is not measured by the dyno. These factors are usually measured warm by allowing the dynamometer to spin to rest from a high speed. Analysis of the "spin down" velocity can be converted into Torque vs. Speed, and converted into the appropriate frictional compensation factors.

Demonstration: Frictional Compensation

During "spin down" the inertia is decelerated by friction from bearing, windage. We can measure the speed profile, and calculate the deceleration to determine the friction.

Motion

Friction

Torq = I x Alpha

RPM

Time

Torque

RPM

y = 4E-05x + 0.0409

(chart: Crictional Torque (Nm) vs Motor Speed (rpm))

Last Cal is the numeric version of the last calibration date.
Dyno Type is usually either "Engine" or "Chassis".
Roller Diameter pertains to the roller size on chassis dynamometers.
Inertia is the total inertia of rotating components of the dynamometer. Note: This does not include the rotating inertia of the parts of the motor or vehicle which is spinning the dyno. In some cases the dynamometer is an "Inertia only" dynamometer, and does not have active loading, just a rotating mass accelerated by the power source. In this case the torque is calculated from the acceleration of the inertia via the following:

Torque = Frictional Offset + Frictional Factor x RPM + Inertia x Acceleration (rad/s/s)

In loading type dynamometers, Torque is calculated similarly, by the measured torque (usually the largest component) is added in. To eliminate inertia calculations, set the Inertia to zero. To eliminate frictional compensations, set the frictional factor and offset to zero.

The Communication Ports of the various dyno components are then listed. Typically each piece of equipment is connected to the computer via a USB-Serial com cable. These generally require a driver, and you can determine the address of each port from HyperTerminal or other serial communications program. If, when the Dyno Monitor program is started the selected serial port is not correct, it will open a message box, requesting the correct serial port number.

The next 4 factors (labeled A, V, V, V in this cal file) are the labels and factors of the Analog Channels 1, 2, 3 and 4 respectively, and the following 4 are the analog channels offsets. The Analog Inputs are 0-5V, and converted to Volts in the software. In this example we have a wide-band exhaust gas O2 sensor on Channel 1 (thus the label "AFR" for Air Fuel Ratio) where 8V is equal to 8.5AFR, and 5V is 23.5AFR. Using the proper labels and scaling factors (Unit/Volt) will result in a display of the proper value on the front screen and in the data file.

The various graphs are scaled to Speed and Torque (and Power = Speed x Torque) by the X and Y Scale Max Values. These can be reset from the main view of the Dyno Monitor program. Finally the last used Batch file (.BAT), and Drive Cycle (.DRV) are listed in the Dyno Calibrations file.

Major Display Areas

Speed, Torque, Load and Throttle Gages and History

Various Calibrations and Auxiliary Factors

Power Gage

Analog Inputs History

Speed and Torque Curves

Analog Inputs

Batch File Data Logging File Name

Fuel Scale Data

Raw Controller Data

Drive Cycle File

Major Controls

Calibrations

This button clears the Torque/Power Graph

Analog Factors And Labels

Remote Commands: Mode Setpoint and Throttle

Drive Cycle On/Off

Logging on/off
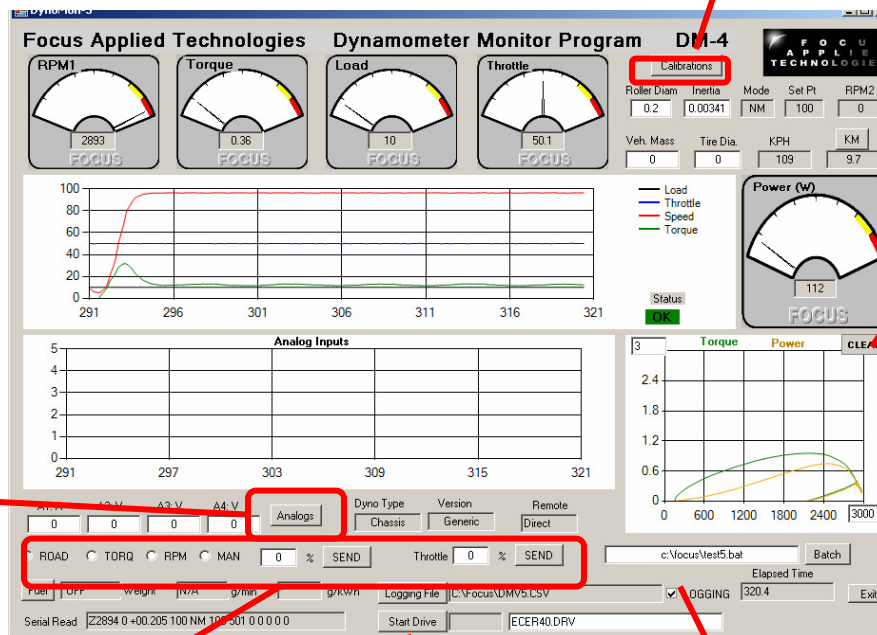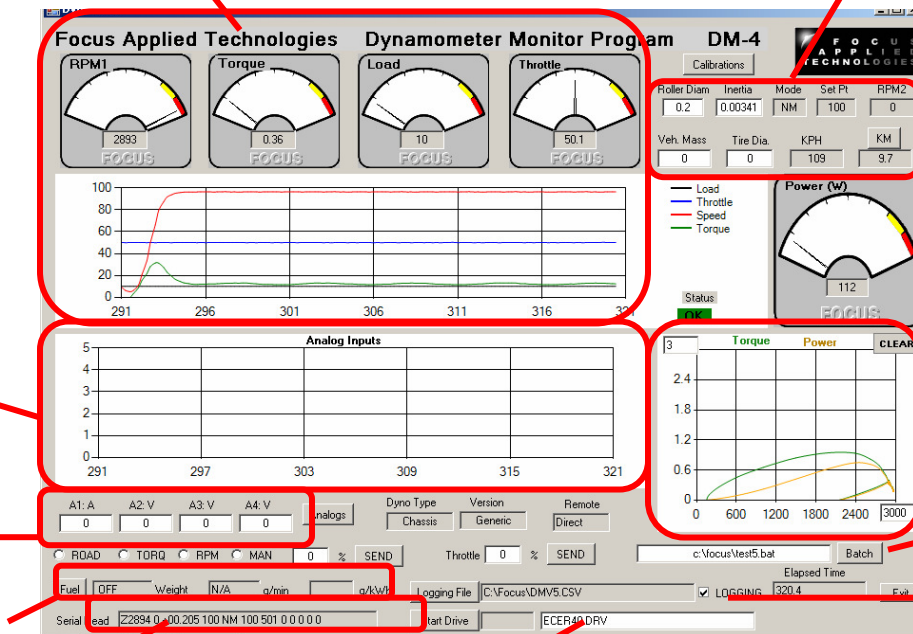
The dyno controller receives one ping per 250ms in verbose mode. When Verbose mode is OFF, the controller software must "ping" the dyno controller with a "A" character to elicit the dyno's response. The dynamometer controller sends data as numerical characters at 9600 baud, 8bits, 1 stop bit, no parity. The raw data is shown in the lower left of the screen.

Speed (RPM1) Torque (in Nm), %Load and %Throttle are all sown in the dial gages at the top. Power is displayed in the dial gage on the far right. The top graph in the center of the screen is the history (last 30 sec) of Load, Throttle, Speed and Torque. The Maximum (ie. 100%) values of Speed and Torque are the "T-Graph Max X" and T-Graph Max Y" numbers set in the boxes on the Torque and Power graph on the lower right. The History of the Analog Inputs is displayed in the lower, central graph, on a 0-5V basis. The Analog labels and values are displayed in the 4 boxed just below the Analog History graph.
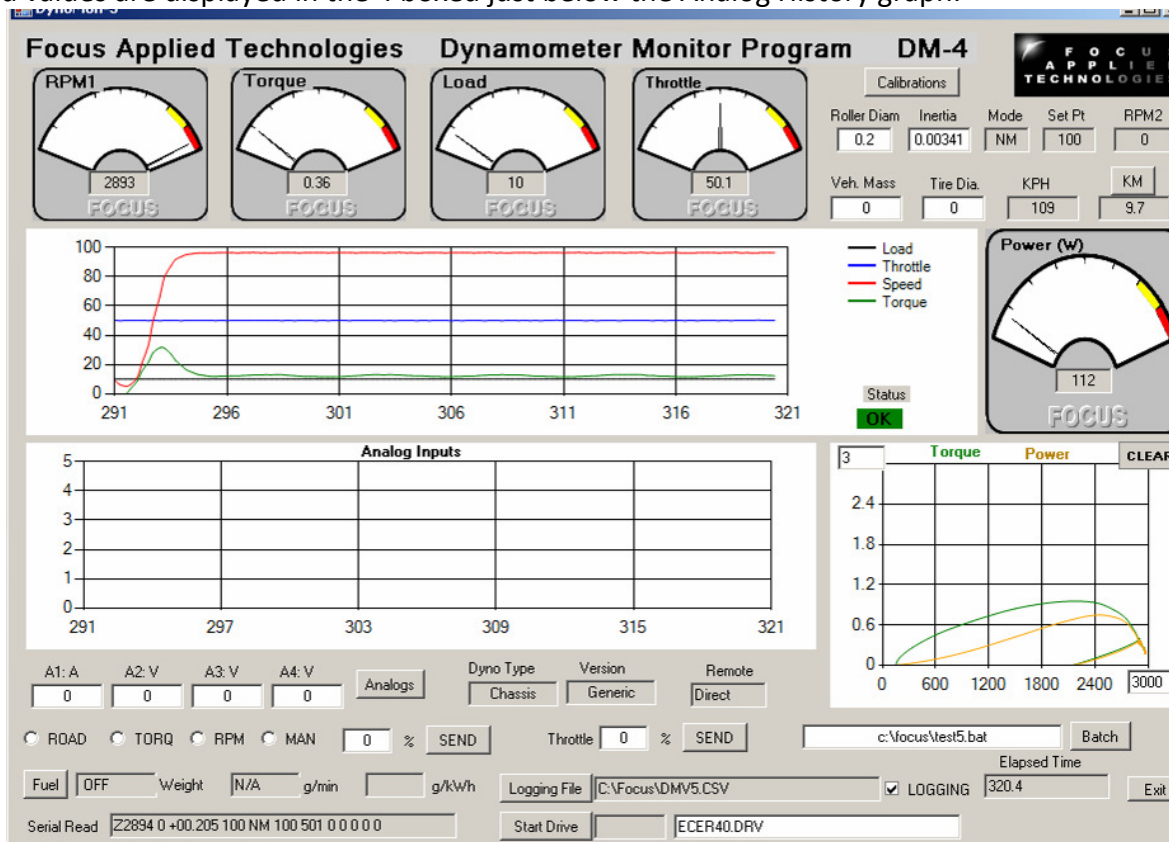
Various calibrations are displayed in the upper right corner of the display. Roller Diameter, Inertia, Vehicle Mass and Tire Diameter can be edited directly in these boxes. The MODE box displays the controllers Mode (M for Manual, S for Speed, T for Torque, and R for Road Load, the prefix "N" stands for "Normal" or dyno front panel control, and "C" is for "Computer" controlled mode, where you control the mode from the dyno monitor front panel, or from a batch file). The Set Point is the actual set point in the selected mode. Note: This may be scaled differently, ie Manual load of 12.5% appears as NM, 125. The 2nd speed input (RPM2) is also displayed, along with the speed (in km/hour) and an Odometer, which is resetable. The conversion to speed is done via the roller diameter.

Remote (controller must be in the COMputer control mode) Mode and Set Point are in the lower left, just below the Analog display. To send a 2800 rpm set point, click the RPM mode switch, and enter 2800 in the box (which will be labeled RPM) on the right. Hit the SEND button next to it to send. Throttle position is to the right of that.

Logging data file name is edited from the button below throttle, and logging can be turned on/off via the "switch" on the right of the data file name.

A Drive Cycle can be displayed for following. Select the file (a CSV type file with Time, Speed as columns) in the dialog box, and hit the "Start Drive" button to begin. Drive cycle can be halted and repeated as desired.

In COMputer control mode a "Batch" file of commands can be sent for automated testing. The file name can be edited in the Batch File dialog box, and execution begins by hitting the "Batch" button. Again this can be halted, and re-started (from the beginning) any time by hitting the Batch button. A batch file programming guide follows in the next section.

Calibrations

Hitting the "Calibrations" button (upper right) pulls up the Calibrations dialog box as shown below. Numbers can be entered in the appropriate boxes. Temperature, pressure and humidity are used in the SAE compensation for engine power (do not use for electric motors). Compensation can be clicked on by checking the box in the upper right of the power meter labeled "SAE". To close this hit the "Calibrations" button again.

Analog Labels and Factors

The Analog labels and Factors can be entered in the dialog box opened by hitting the "Analogs" button (lower left). Hi the button again to close.

Drive Cycle File

The first line of the drive cycle file is ignored as a header. The subsequent lines are in the format time, speed (usually in kph). The file is a ".CSV" comma separated variable format for easy editing. Below is the 1st "hump" of the ECE-R40 drive cycle pattern.

T	V
0.50,	0.0
1.00,	0.0
1.50,	0.0
2.00,	0.0
2.50,	0.0
3.00,	0.0
3.50,	0.0
4.00,	0.0
4.50,	0.0
5.00,	0.0
5.50,	0.0
6.00,	0.0
6.50,	0.0
7.00,	0.0
7.50,	0.0
8.00,	0.0
8.50,	0.0
9.00,	0.0
9.50,	0.0
10.00,	0.0
10.50,	0.0
11.00,	0.0
11.50,	1.9
12.00,	3.8
12.50,	5.6
13.00,	7.5
13.50,	9.4
14.00,	11.3
14.50,	13.1
15.00,	15.0
15.50,	15.0
16.00,	15.0
16.50,	15.0
17.00,	15.0
17.50,	15.0
18.00,	15.0
18.50,	15.0
19.00,	15.0
19.50,	15.0
20.00,	15.0
20.50,	15.0
21.00,	15.0
21.50,	15.0
22.00,	15.0
22.50,	15.0
23.00,	15.0
23.50,	15.0
24.00,	15.0
24.50,	13.5
25.00,	12.0
25.50,	10.5
26.00,	9.0
26.50,	7.5
27.00,	6.0
27.50,	4.5
28.00,	3.0
28.50,	1.5
29.00,	0.0

Focus Applied Technologies Dyno Monitor Batch Programming Language
Rev 2

Commands: M, S, T, R, P, L, C (T, S, 1, 2, 3, 4), E
Labels: 1, 2, 3, 4, 5, 6, 7, 8, 9

M: Manual Mode in 10 times % (eg. 33.3% is M333)
S: Speed Mode in RPM
T: Torque Mode in Nm
R: Road Load constant (0 to 255)
P: Throttle Position in 10 times % (eg. 12.3% is P123)
L: Loop back to label
C(T, S, 1, 2, 3, 4): Control Throttle (software servo) based on Speed, Torque, or Analog input #1, 2, 3 or 4
E: End

M, S, T, R, P command Syntax:
M#, $ where M is the mode (M, S, T, or R) # is the set point value, and $ is the duration in seconds.
The comma and seconds can be excluded if not required.

Control Command syntax:
C, Channel, Command, Set Point Value, Throttle Step Size, Duration (in sec)

Valid Command Examples:
M123	Manual Load 12.3%
M0,2	Manual Load 0%, then pause for 2 seconds
S3600	Speed Control Mode, 3600 rpm
S2400,1	Speed Control to 2400, pause 1 sec
T12.3	Torque Control Mode at 12.3Nm
R123	Road Load at 123% of nominal
R100,10	Road Load at 100%, pause for 10 sec
P0	Throttle Position to 0%
P500,6	Throttle Position to 50.0%, pause 6 sec
1	Label #1
L1,2	Loop back to label #1 2 times
C4,3,1.5,10	Control Throttle in (increments of 1.5%) so that Analog Input #4 becomes 3V for 10 sec
END	End. Stop batch execution and return to direct control from screen

Example Batch Program:
M0	Manual Mode, 0% Load
P500,5	Throttle Position to 50%, Dwell 5 sec
S3000,5	Speed Mode, 3000rpm, Dwell 5 sec
1	Label #1
S2900,5	Speed Mode, 2900rpm, Dwell 5 sec
S2800,5	Speed Mode, 2800rpm, Dwell 5 sec
L1,2	Loop to Label #1, run twice (total)
M0	Manual Mode, 0% Load
P900,5	Throttle Position 90%, Dwell 5 sec
2	Label #2

M200,5				Manual Mode, 20% Load, Dwell 5 sec					
M300,5				Manual Mode, 30% Load, Dwell 5 sec					
L2,2			Loop to Label #2, run twice (total)						
P500			Throttle Position to 50%						
M0			Manual Mode, 0% Load						
CS,2800,1.5,10			Control Throttle to get Speed to 2800 rpm, increment throttle 1.5% for 10 sec						
S3000			Speed control at 3000rpm						
M0			Manual Mode, 0% Load						
P0,5			Throttle Position to 0, Dwell 5 sec						
END			Quit Batch Mode						

Logging Data File

The data is continuously saved to the designated file as follows:
Time in seconds, Main Roller speed in rpm, Torque in Nm, % dynamometer load, Throttle position, Controller mode (described above in Computer Communications section), Set point (mode dependent), Friction in Nm (a function of speed), Acceleration in M/s^2, and the analog input voltages 1, 2, 3, and 4 respectively.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Focus Applied Technologies Dynamometer Data Log												
2	File Opened: 63475828548.14												
3	Time	RPM	Torq(Nm)	%Load	Throttle	Mode	SetPt	Frict(Nm)	Acell(m/s)	Ch1	Ch2	Ch3	Ch4
4	5.296997	0	0	1.9	3.9	NM	19	2	0	5	5	5	5
5	5.563004	0	0	5.8	3.9	NM	57	2	0	5	5	5	5
6	6	0	0	8	3.9	NM	79	2	0	5	5	5	5
7	6.046997	0	0	10.7	3.9	NM	105	2	0	5	5	5	5
8	6.296997	0	0	16.8	3.9	NM	165	2	0	5	5	5	5
9	6.563004	0	0	19.8	3.9	NM	194	2	0	5	5	5	5
10	7.030998	0	0	23.4	3.9	NM	229	2	0	5	5	5	5
11	7.046997	382	0	29.8	3.9	NM	292	2.764	0	5	5	5	5
12	7.313004	882	13.58009	30	3.9	NM	294	3.382	3.590241	5	5	5	5
13	7.75	1286.5	27.34808	34.4	3.9	NM	337	3.691	7.230161	5	5	5	5
14	7.844002	1383.75	27.87659	37.3	3.9	NM	365	3.481	7.369884	5	5	5	5
15	8.046997	1073.875	80.82412	39.4	3.9	NM	386	2.764	21.36791	5	5	5	5
16	8.313004	729.9375	45.56084	44.2	3.9	NM	433	2.386	12.04517	5	5	5	5
17	8.765999	461.4688	19.66562	45.7	3.9	NM	447	2.193	5.199107	5	5	5	5
18	8.844002	278.7344	7.956489	48.4	3.9	NM	474	2.096	2.1035	5	5	5	5
19	9.046997	163.3672	-50.1613	52.9	3.9	NM	518	2.048	-13.2614	5	5	5	5
20	9.485001	93.68359	-39.2142	53.2	3.9	NM	521	2.024	-10.3673	5	5	5	5
21	9.546997	52.8418	-29.9272	56.9	3.9	NM	557	2.012	-7.91201	5	5	5	5
22	9.780998	29.4209	-22.4064	58.2	3.9	NM	569	2.006	-5.92371	5	5	5	5
23	10.047	16.21045	-16.1734	61.2	3.9	NM	599	2.003	-4.27585	5	5	5	5
24	10.5	8.605225	-13.9794	64.4	3.9	NM	630	2.001	-3.69582	5	5	5	5
25	10.547	4.302612	-10.0916	66.1	3.9	NM	647	2	-2.66798	5	5	5	5
26	10.781	2.151306	-7.2269	70.3	3.9	NM	688	2	-1.91061	5	5	5	5

This data can then be graphed and analyzed further.

Alternative Data Logging

An alternative option for data logging is via any serial communications program, such as Hyperterminal or RealTerm. Simply connect to the dyno controller, insure that the controller has Verbose mode ON, and save the resulting data to a text file. This text file can then be loaded into a spread sheet such as Excel and the various columns can be converted to data as mentioned above in the Computer Communications section above.

SAFETY PRECAUTIONS

The Focus Applied Technologies Chassis Dynamometer is designed to be an inherently safe machine via the use of heavy duty bearings and frame, electrical fault protection, and ignition cutoff system. However as with any large power equipment improper use can result in a hazardous situation.

With this in mind here are several tips to help keep the users safe:

- Always maintain the belts, pulleys and wires in good condition and at the proper tension.

- Always make sure the test vehicle is firmly secured to the dyno

- NEVER STEP on a moving roller!

- Avoid loose items including cloths, cables, belts and loose small times which might fall into the gap between the roller and the dynamometers kick plate.

- The control boxes contain dangerous voltages and currents. Never operate the dynamometer with the control boxes opened.

- Make sure the dynamometer is firmly bolted to the floor, and the test vehicle is strapped to the dyno so that it can not accidentally slip out.

- Disconnect all power to the dynamometer and auxiliary components before opening or servicing.

- Insure proper ventilation whenever operating a combustion engine.

NEVER allow personnel to access the inside of the dynamometer while in operation. Fingers and articles of clothing can be pulled into the moving rollers and/or belts potentially maiming the user.

ELECTRICAL HAZARDS

This equipment is powered by potentially dangerous AC and DC voltages, and normal precautions pertaining to electrical appliances apply. Do not operate the equipment if there is water present in, on, or around the equipment. Make sure all electrical wiring is properly installed and grounded, and has a fast-acting Ground Fault Interrupter in the circuit.

The power from the dynamometer to the dump load is to be considered a **HAZARDOUS VOLTAGE**, which may be as high as 400VAC. It is imperative that the dump load and wiring be routed in such a way at to prevent the possibility of contact with any conductive object or personnel. Additionally the dump load may become **VERY HOT** in operation. Make sure it is mounted away from any flammable objects, or anything that could be damaged by elevated temperatures.

MECHANICAL HAZARDS

This equipment may be operating at high speeds, and rotating equipment is always a potential hazard. Keep hands, hair and cloths clear of the rotating shafts (especially the speed target wheel). Inattention may allow a loose article of clothing (ie. a shirt sleeve, neck tie, or head scarf) to become entangled in the rotating shaft, potentially injuring **OR KILLING** the person.

Equipment featuring a Universal Joint shaft can be dangerous if overloaded. Although the shaft selected may be operating within the designed specifications, it could possibly become damaged, or fail, resulting in an outward explosion of the shaft, throwing heavy components outward at high speed. **ALWAYS STAY WELL AWAY FROM THE UNIVERSAL JOINT/COUPELER/BELT/PULLY AREA WHEN IN OPERATION!**
If this unit is intended for intense usage with personnel in close proximity, then a universal joint explosion cover should be affixed.

FIRE HAZARDS

As always, when operating engines high temperatures, sparks and fuel are present. Take all necessary precautions and **always** have a fire extinguisher on hand.

TROUBLE SHOOTING GUIDE

If you encounter problems with the dynamometer, there are some simple tests and checks you can perform to help you track down the source of the problem. A dynamometer and controller is a complex system, and very often problems are related to improper external wiring or usage of the controller. The following simple tests should help you diagnose what is wrong with the system and correct it.

DYNAMOMETER POWER TEST

Apply power to the Dynamometer Coils. This can be done by directly running power in (ie. connecting to a 12V battery) or by placing the dynamometer controller in manual mode and setting it to 20% load. The shaft of the dynamometer should have significant resistance to rotation. Remove the power from the dynamometer coil and the shaft should spin freely. If applying power to the dynamometer coils does not result in a loaded shaft than either the rotor (dyno coil lines) or the stator (dump load lines) are open. Check the resistance across both lines. The Dyno Coils should have a resistance of between 10 and 100 ohms. The dynamometers stator (the wires going to the Dump Load) lines should have a resistance below 20 ohms when disconnected from the dump load. The Dump Load should have a resistance of between 10 and 50 ohms. If any of these are out of specification the dynamometer will not be able to apply the appropriate load to the shaft.

DYNAMOMETER CONTROLLER POWER TEST

Apply a load to the Dynamometer Coil Output: a 500 ohm, 10W power resistor can be used to simulate the coil load. In Manual Mode you should be able to see a signal on the Dynamometer Coil Output lines. At low load the DC voltage across the load should be low, and should go up to over 50V at full load. This can be measured with either a volt meter, or on an oscilloscope. On the oscilloscope you should be able to see wave forms something like that in the Sample Signal section of this manual. If you get this DC voltage, then the power supply, power switching transistor and controller are all working properly. If you do not, try resetting the circuit breakers, checking wire connections and trying again.

SPEED SIGNAL TEST

The speed signal must have sufficient amplitude to trigger the speed sensing circuitry. Typically this will require a zero-to-peak amplitude of at least 1V. For accurate speed measurements, the signal should not have any noise exceeding this threshold. With the dynamometer spinning the speed pickup signal can be viewed on an oscilloscope. The signal should look like one of those in the Sample Speed Signals section. The actual speed is calculated from period of **n** transitions, where **n** is the number of pulses per revolution. On the oscilloscope trace you should confirm that all **n** of the transitions exceed the threshold level, and none of the noise spikes do.
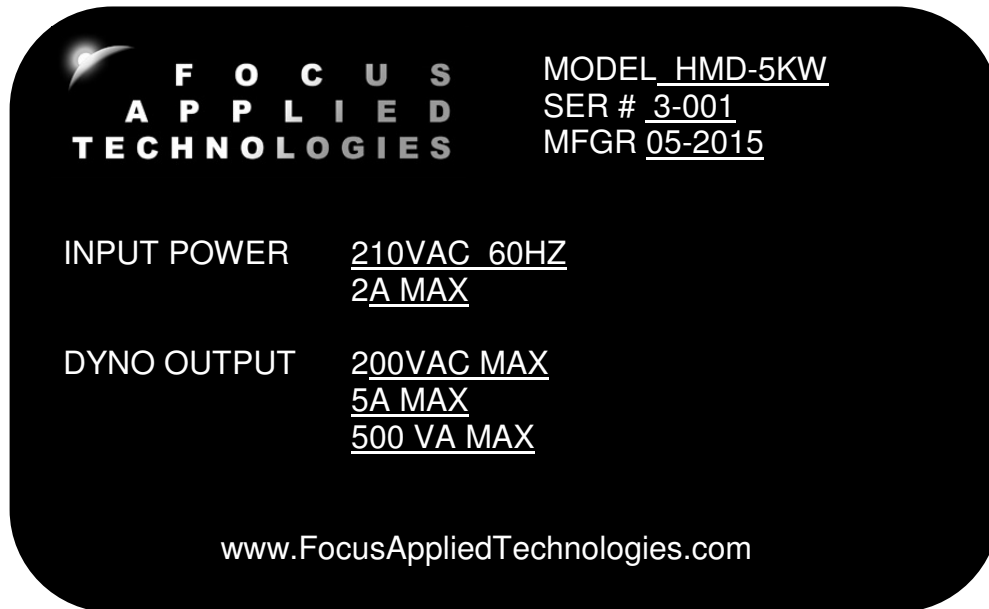
LOAD CELL TEST

The load cell and amplifier can easily be tested together by observing the voltage (amplifier output which should be fed into Torque Input terminals on the back of the controller) while changing the load on the load cell. Unloaded the amplifier should have a small DC voltage (the "zero voltage"). As

load is applied this voltage should increase linearly proportional to the applied load. If the voltage *decreases* when applying load in the nominal loading direction, reverse the **Sig +** and **Sig –** lines on the amplifier; this will cause the voltage to increase with applied load. When the load is removed the voltage should decrease back to the initial "zero voltage". If the assembly does not behave as indicated, it is likely that there is a problem with the load cell wiring, and you should proceed to the following "Load Cell Trouble Shooting" section.

CONTACT INFORMATION

As there are so many factors outside of our direct control, Focus Applied Technologies does not assume any liability for accidents caused by the use of this equipment. Use of this equipment is at the users own risk. If any problems or accidents occur, we wish to be informed so that we may improve our products, and fix any issues they may have. Please send us any feed back you have regarding the use of this equipment.

F O C U S
A P P L I E D
T E C H N O L O G I E S

MODEL HMD-5KW
SER # 3-001
MFGR 05-2015

INPUT POWER   210VAC 60HZ
               2A MAX

DYNO OUTPUT   200VAC MAX
               5A MAX
               500 VA MAX

www.FocusAppliedTechnologies.com

For further information on this or other products please contact us via the following:

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             Sungai Jawi 14200
             PENANG, MALAYSIA