



FOCUS APPLIED TECHNOLOGIES DYNAMOMETER SYSTEM DYNO MODEL BD-10KW CONTROLLER MODEL DC5

Manual Rev. 5-1014

10kW GENERATOR DYNAMOMETER WITH CONTROLLER

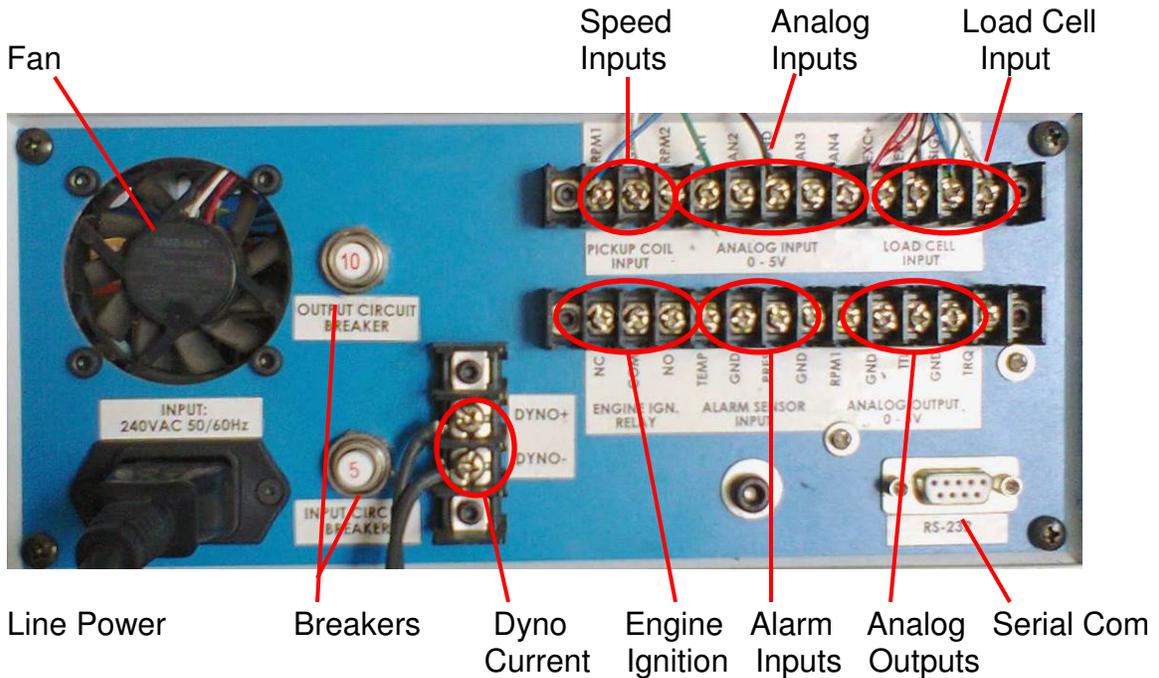


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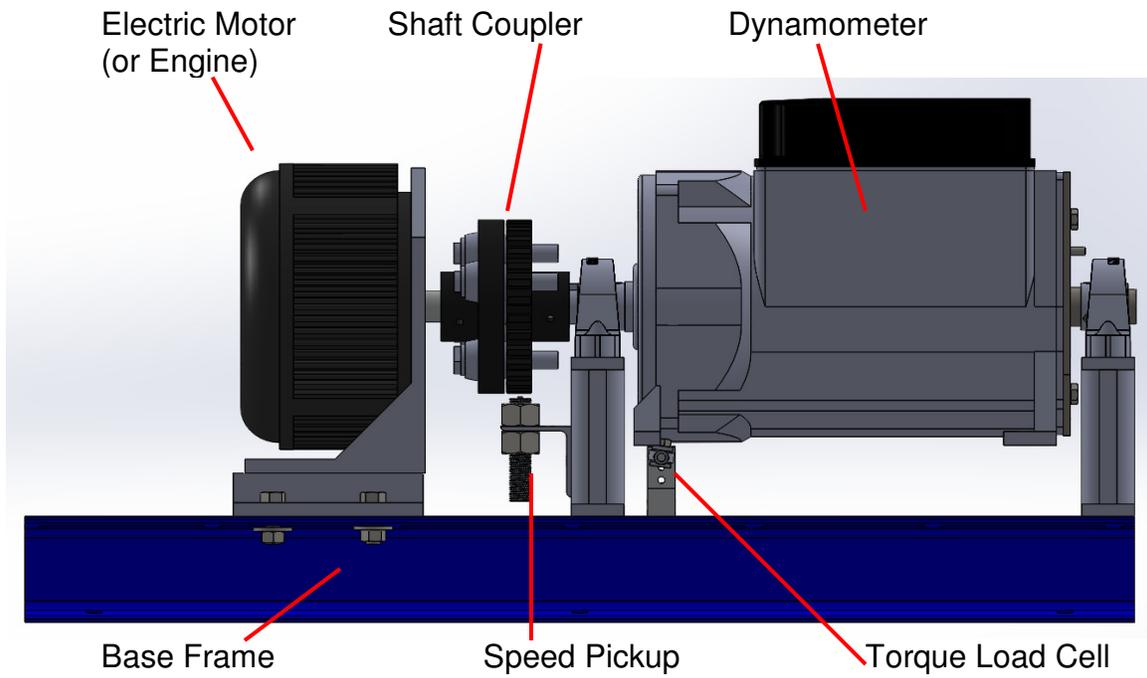
CONTROLLER FRONT VIEW



CONTROLLER REAR VIEW



DYNAMOMETER SIDE VIEW



FEATURES

Dynamometer

The dynamometer is a generator-type “eddy current” dynamometer. Power from the engine or motor rotates the rotor of the generator. The rotor field is controlled by the dynamometer current. More current gives a stronger rotor magnetic field, inducing more power in the stator coils. Power from the stator coils is sent to a dump load located distant from the dynamometer. The dynamometer is suspended on bearings, and torque is read by a load cell. 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 (RPM²) and Computer (remote) mode. Which of these modes to use depends on the specifics of your 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. 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. 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 is 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. $5 \cdot 123 / 1023$)

Analog Input 2 is 1.686V

Analog Input 3 is 3.314V

Analog Input 4 is 5.00V

Data Acquisition System

Some systems feature an integrated USB Data Acquisition System (DAQ). This system is a stand alone system for reading signals from various sensors commonly used in engine testing such as Thermocouples, Pressure Sensors and etc. Several channels are left open for the addition of user defined sensors. All of these sensors can be read by the computer data logging software for display and recording. Pressure sensors are also used in a high-speed mode where the pressure is recorded and

displayed allowing the change in pressure to be viewed through out an individual engine cycle.

Fuel Scale

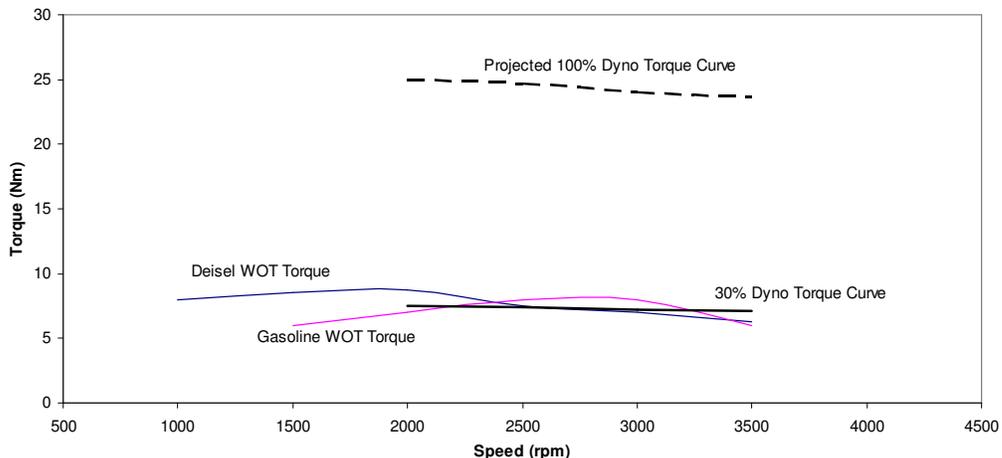
This digital gravimetric fuel scale weight fuel as it is consumed by the engine under test. The data is fed to the computer via serial (RS-232) communications link, allowing seamless integration with our dynamometer and DAQ systems. The weight of fuel is measured as a function of time allowing direct 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.

Dump Load

Power extracted from the engine is sent al electricity to the dump load where is heats air. The dump load is a high quality industrial heater, and is operating at relatively high temperatures (in excess of 100C) and voltages (up to 400VAC). This heater should be rigidly mounted to a wall high up out of the reach of people and out of the way of any equipment. This system should be inspected before operation of the dynamometer and maintained if required.

Power

The generator in this dynamometer is nominally rated at 5kW electrical at 3000rpm. As the efficiency of this device is relatively low, generally around 50%, it absorbs significantly more mechanical power, and has a nominal rating of 10kW mechanically. Measured data from the dynamometer shows that at 30% load it extracts 7.5Nm of torque. Thus at 100% load it should extract approximately 24Nm, which, at 4500 rpm (maximum speed) is 11.5Kw of mechanical power.



SPECIFICATIONS

DIMENSIONS

LxWxH: 1200 x 490 x 400 mm
Weight: Approximately 65kg (without engine)

POWER IN

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

CONTROLLER OUTPUT

Resistance: 10 ohms minimum
Power: 300W maximum
Voltage: 50V nominal
Current: 5A maximum

DYNAMOMETER POWER

Mechanical Power: 10,000W maximum
Torque: 22Nm maximum
Speed: 4500 rpm maximum (direct coupling)
9,000 rpm (using 2:1 pulley)

Electrical Power: 5,000W maximum
Voltage output: 300V maximum
Current: 25A maximum

INPUTS

Speed Input: Variable Reluctance type input
1 to 60 pulse per revolution
30V pk-pk maximum
60 to 10,000 rpm (typical)

Strain: 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. These 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. Check Dump Load
3. Turn Computer ON
4. Turn Dynamometer Current to the OFF position
5. Switch the Mode selector switch to MANUAL mode
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 Set Point Adjust to 0%
9. Set the Throttle Set Point to IDLE

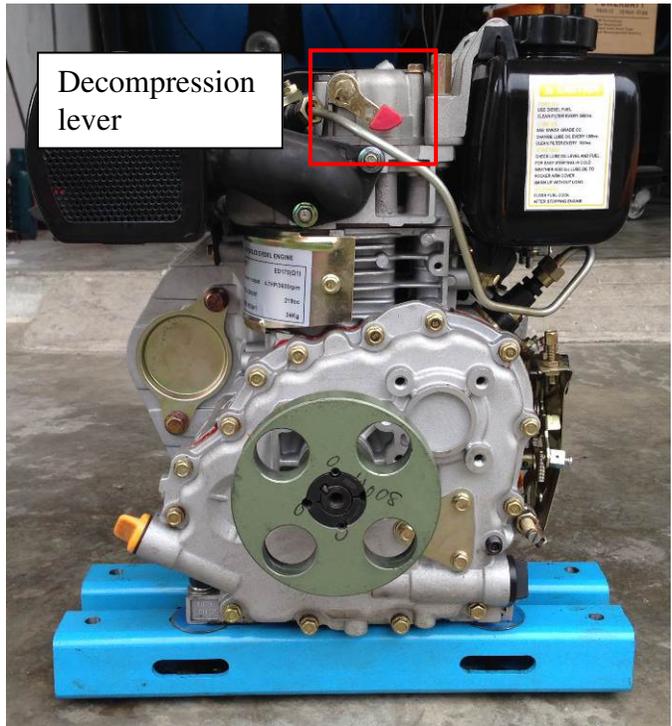
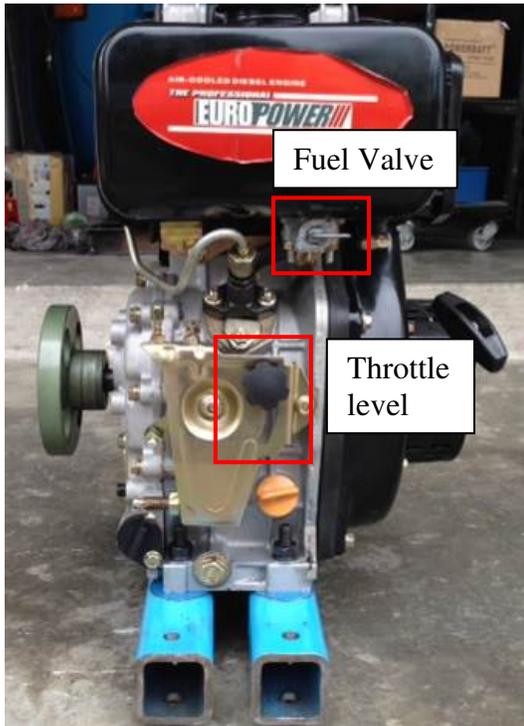
Fuel Scale Startup Procedure

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

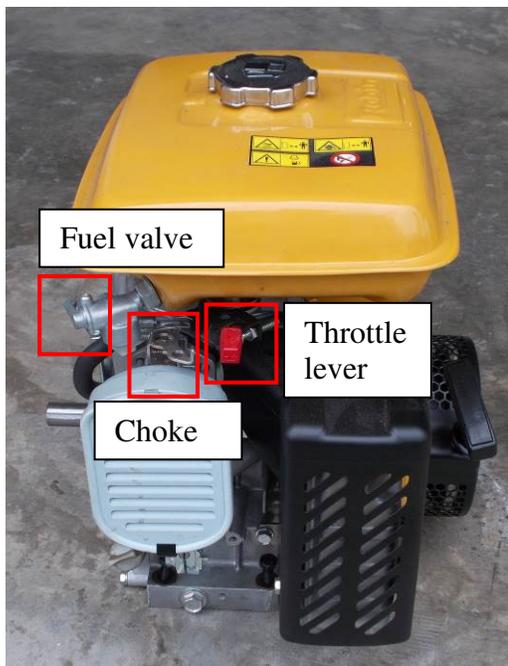
Engine Startup Procedure

1. Check the Engine Oil and Coolant levels
2. Check Engine – Dynamometer shaft and alignment
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 (for gasoline engine) or push down the decompression lever (for diesel engine)
8. Place Throttle to the START position (IDLE)
9. Start the engine and IDLE

Diesel engine



Gasoline engine



Engine 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 or 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

MODES OF OPERATION

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 Mode (MAN)

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 speed. Dyno load is increased as the throttle is opened to keep the engine just at redline speed. Once the throttle is full open, the torque and speed are recorded. Subsequently the load is 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.

Speed Control Mode (RPM)

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 knob 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 $100 \times 128 / 1024$ 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 less 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 every 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
000000	+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
000000	+0.0000	>000
>02500		SPD

RPM	TORQUE	%LOAD
SP RANGE MAX:	>500	

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

RPM	TORQUE	%LOAD
FP	FI	FD
>00500	05000	00000

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
TORQUE	>035	000 015

RPM	TORQUE	%LOAD
FP	FI	FD
>00500	05000	00000

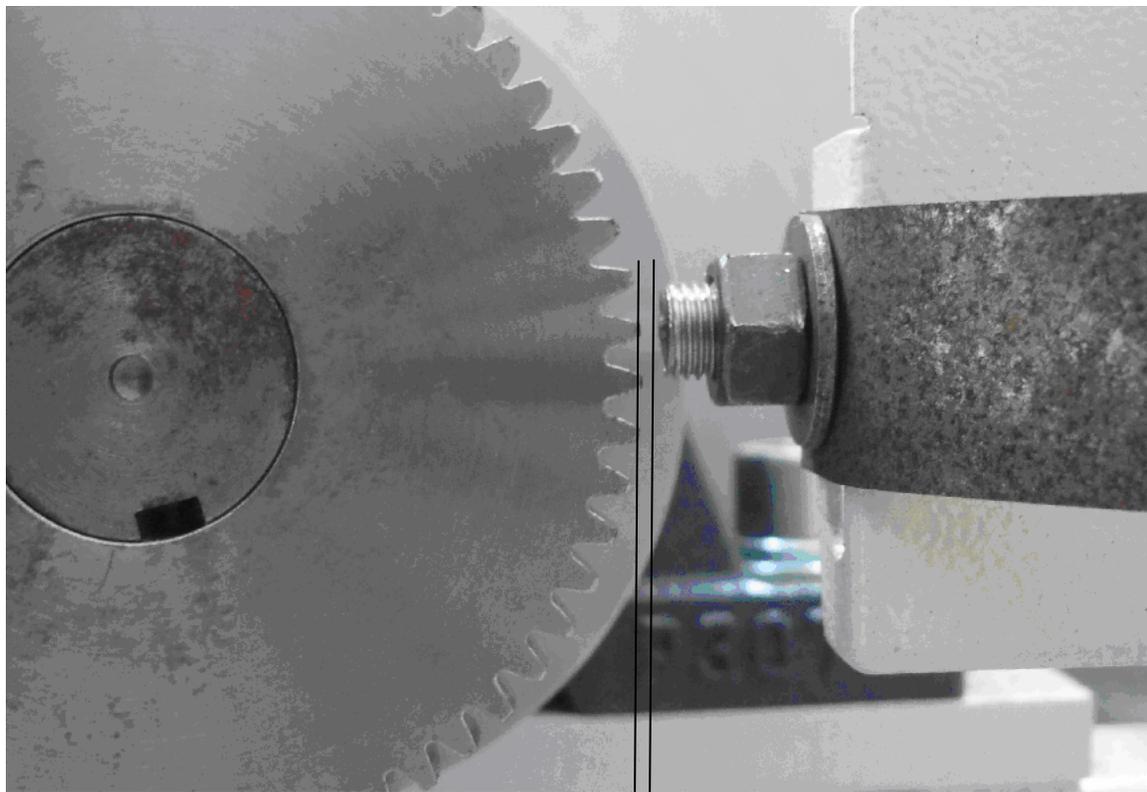
RPM	TORQUE	%LOAD
	SAVE CONFIG?	
	>NO	

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 30 teeth. 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 it is 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 1mm. The acceptable range is 0.5mm to 1.5mm.



Gap: 0.5mm to 1.5mm

Torque Calibration

A calibration arm is provided with the dynamometer. This needs to be bolted to the dynamometer as shown below. Once the arm is loaded the load should be zeroed at the dynamometer controller. Simply hit the TARE button on the front panel to zero the torque. Calibration weights can now be added to the cal-arm at the indicated location. This places the weights 0.20m from the centerline of the dynamometer. The torque reading is the MAIN ROLLER torque, ie. twice that of the dynamometer torque, thus the torque resulting from a mass M is:

$$\text{Torque} = M \times 9.81 \times 0.20 \times 2$$

Where:

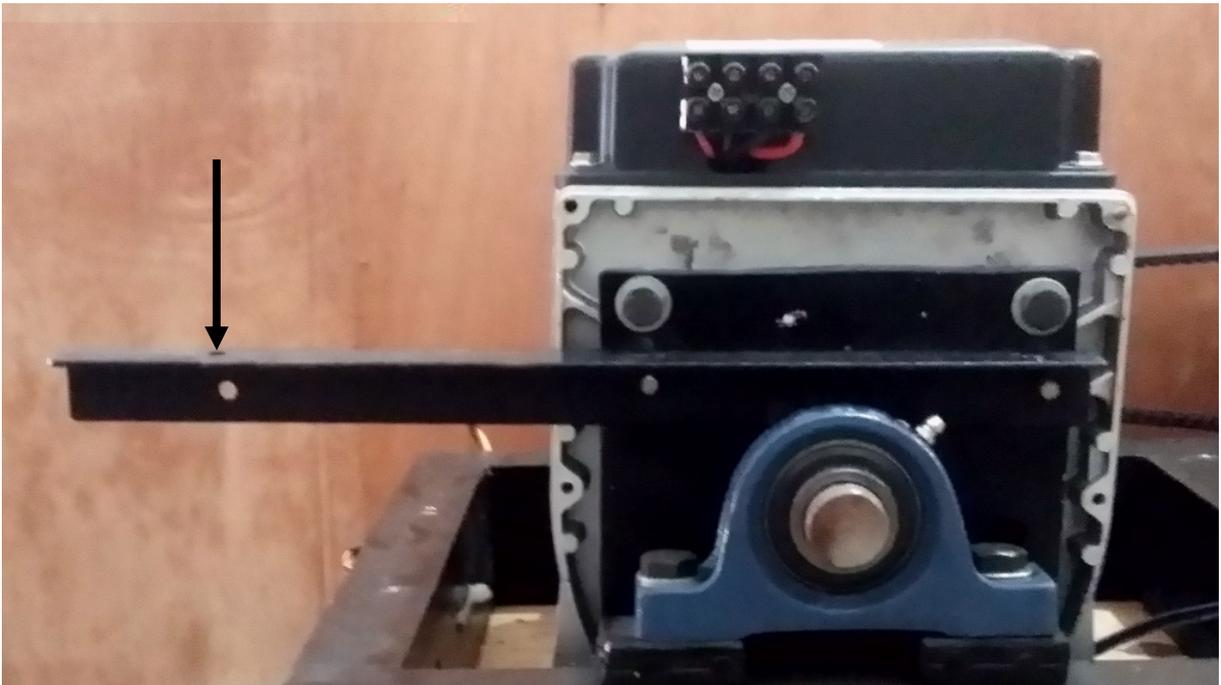
M is the weight of the mass in kg

9.81 is standard gravitational acceleration

0.20 is the radius of the weights in meters

2 is the gearing ratio to the main roller

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.



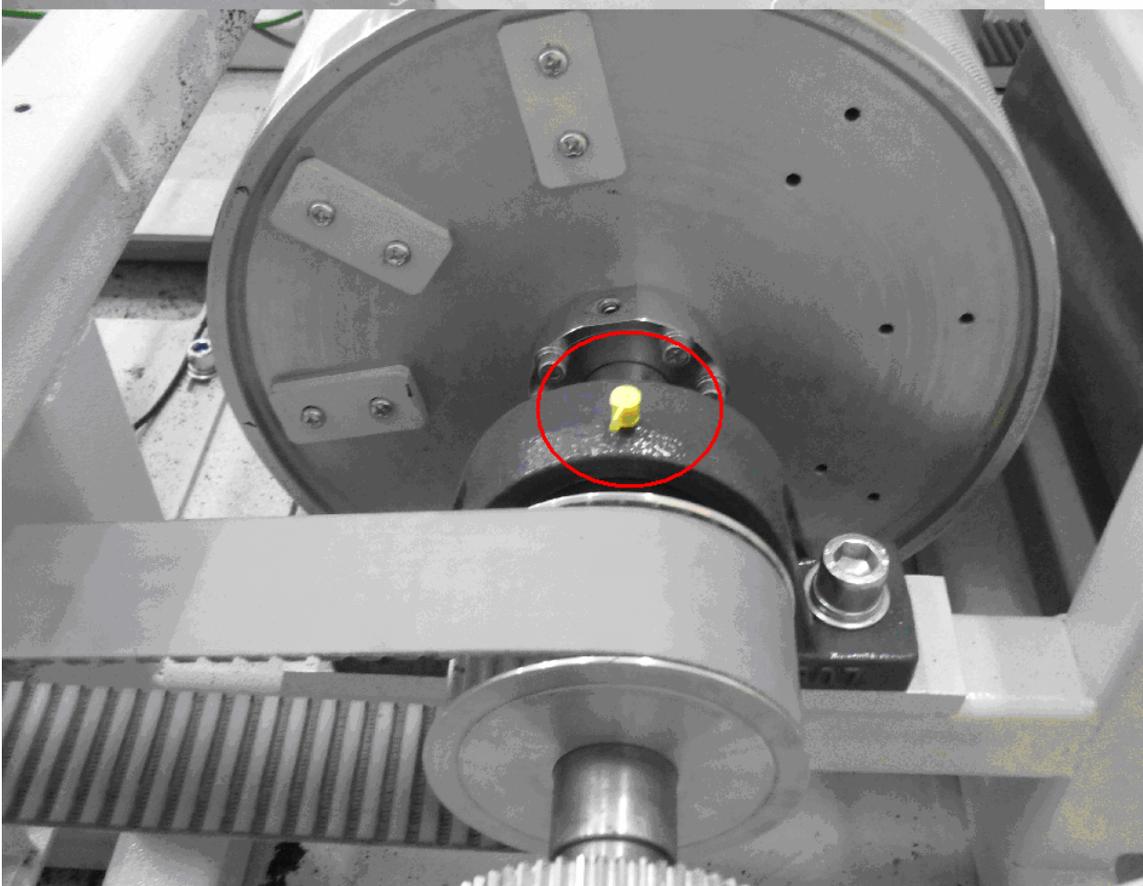
MAINTAINENCE GUIDE

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 greasing annually, the belts require periodic tensioning, and may eventually require replacement. Each of these is described separately below.

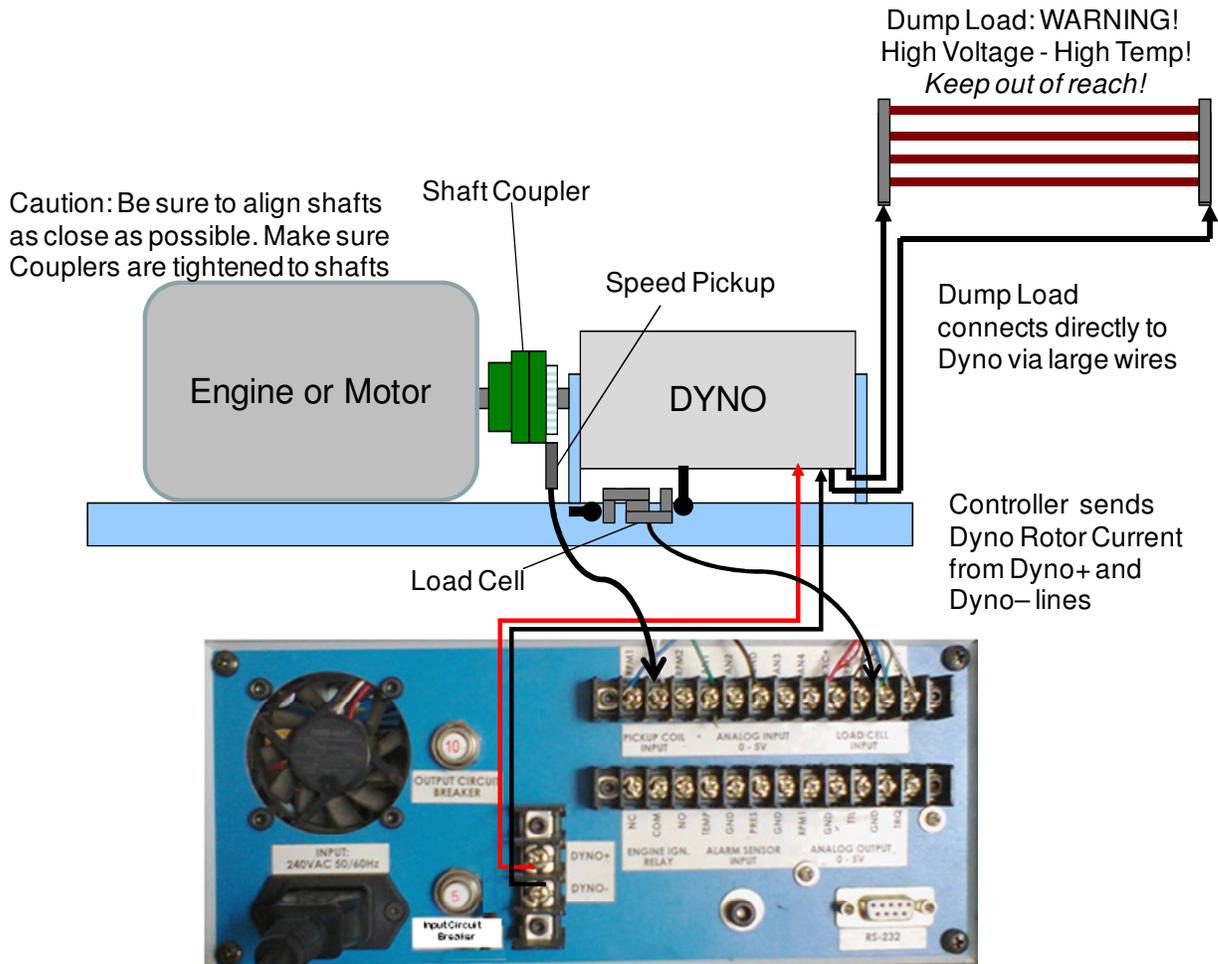
Grease Roller Bearings

There are four pillow-block bearings, one at each end of the main roller and one at each end of the idler roller. The bearings have a nipple at the top for addition of grease (red circle in foto below). Fresh grease needs to be applied periodically. This can be added with a grease gun by clipping the grease gun to the nipples and delivering a few pumps. This should be done once each year, or every 300 hours of operation.

CAUTION: Do not add so much grease that it leaks from the bearings seals.



EXTERNAL WIRING DIAGRAM



The Controller unit is powered from a clean AC line power source.

The Dynamometer's Rotor coils are connected to the Dyno+/Dyno- Output of the controller with power cables. The resistive load is non-polar, and the signal is up to 400V AC at over 10A, so be sure the wires are heavy gage, and in good shape.

WARNING: Both the Dyno+/- control lines and the Dump Load 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 non-polar and should be approximately 2 to 30V AC depending on the speed and proximity of the sensor to the speed target wheel.

The load cell amplifier is connected to the appropriate connections on the dyno controller, typically:

RED = Excite+, BLACK = Excite -, YELLOW or WHITE= Sig+, ORNGE or GREEN = SIG-

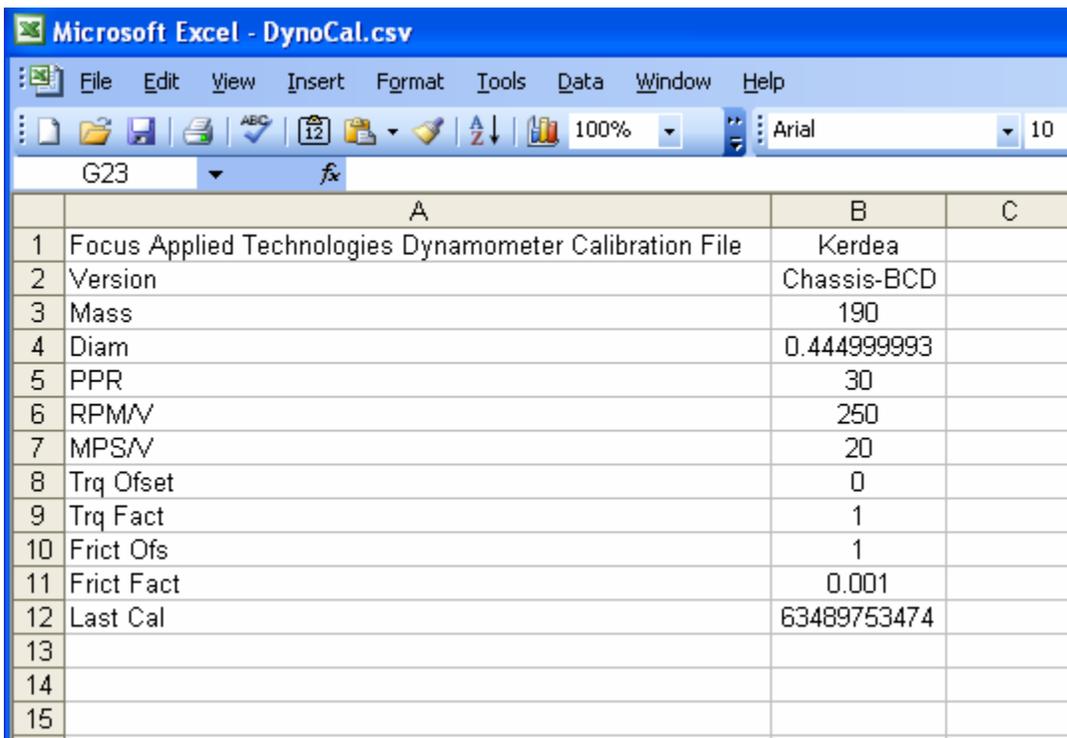
Serial port communications are via RS232: 9600 baud, No parity, 1 Stop bit. The cable should be a "straight through" cable connecting pins 2, 3, and 5 at both ends. The data from the controller will be decimal coded ACSII number for the speed, torque and other data separated by a space and terminated 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 program requires Agilent Instruments IO drivers to operate. These are provided with the disk accompanying the dynamometer controller, and can be downloaded directly from the Agilent website. Once installed, the runtime dyno monitor program (DynoMonG5-1.VXE or similar) can be run from the command line, or from a shortcut icon.

The program will load various calibration parameters from the file:
C:\Fosuc\DynoCal.CSV

This file is easy to edit in Excell or any test editing program and contains the parameters listed below. Not all parameters are used with every version of Dyno Controller, but the parameters file contains all the standard information, and is saved as a "Coma Separated Variables" file.



	A	B	C
1	Focus Applied Technologies Dynamometer Calibration File	Kerdea	
2	Version	Chassis-BCD	
3	Mass	190	
4	Diam	0.444999993	
5	PPR	30	
6	RPM/V	250	
7	MPS/V	20	
8	Trq Offset	0	
9	Trq Fact	1	
10	Frict Ofc	1	
11	Frict Fact	0.001	
12	Last Cal	63489753474	
13			
14			
15			

The program will then prompt you for a data file in which it will save all the dynamometer parameters during operation. You will then be prompted for the serial port for communications to the Dynamometer controller, and the Fuel Scale. If one of these is not present enter a zero for the port.

In operation the various dyno parameters are displayed, and/or graphed, as shown below. In general the displayed values should agree with toes on the front panel of the dyno controller, with variations diminished via exponential averaging. Note that the

displayed Total Torque is the measured torque plus friction and in the case of inertial dynos plus the torque due to acceleration.



In general the display is self explanatory. The various meters can be re-scaled by changing the range limit numbers in the upper corners of the meters. The graphs can be cleared or rescaled by right clicking on the graph, and following prompts. Analog input channels voltage values are displayed and graphed in the lower logging graph.

If a fuel scale is present, the actual current fuel weight is displayed, along with a one minute fuel consumption average, which is updated every 60 seconds.

In the event of a communications failure the following message may appear:



If this appears it means that the software was unable to communicate with the dynamometer controller through the designated port. This is generally the result of one of the following:

- 1) The dyno controller is not powered on, or not connected
- 2) The Serial Communications Port is incorrect for the connection
- 3) USB – Serial port converters are often subject to Electro-Magnetic Interference which can cause them to become inoperable. This can be remedied by disconnecting and then reconnecting the offending USB converter.

In the event of an “Alarm” situation, the ignition relay will be powered off, and throttle command will go to zero, while the “Alarm” button will show ALARM in red. Clear the offending alarm (temperature, pressure, overspeed or over torque) and reset the alarm from the keypad to clear the alarm state, and continue testing. NOTE: Dynamometer

power IS NOT released in an alarm state. This is done intentionally to prevent runaway of the dynamometer.

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/s², 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	Torg(Nm)	%Load	Throttle	Mode	SetPt	Frict(Nm)	Accl(m/s ²)	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. 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 CONSIDERATIONS

POTENTIAL HAZARDS

The Focus Applied Technologies Bench 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, pullies 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 voltage, 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 as 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

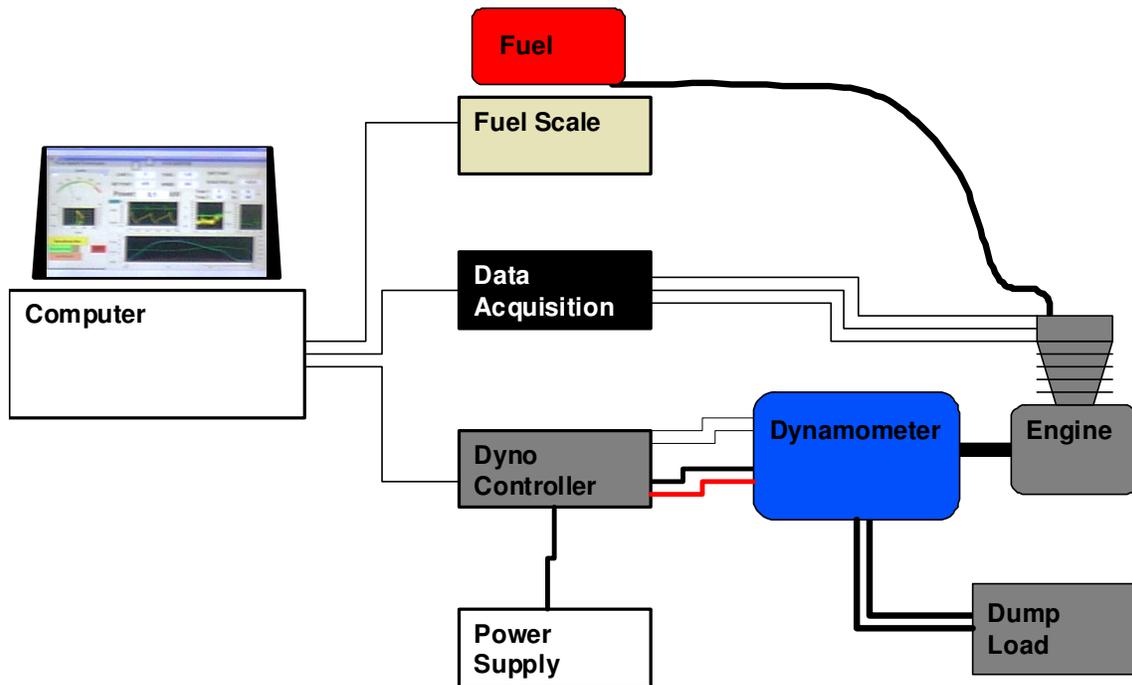
This equipment may be operating at high speeds, and rotating equipment is always a potential hazard. Keep hands, hair and cloths clear of the rotating shafts (especially the speed target wheel). Inattention may allow a loose article of clothing (ie. a shirt sleeve, neck tie, or head scarf) to become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

FUNCTIONAL BLOCK DIAGRAM



The Dynamometer and Dynamometer Controller together with the engine form a complete system. The Dyno controller reads the speed and torque from the dynamometer and controls the load according to its mode and set point. Power extracted from the engine is dissipated as heat in the dump load.

Data from the dynamometer controller may be displayed and logged on a computer. The data is transferred via serial port connection.

Systems with a fuel scale can record and display the weight of fuel during engine operation. As fuel is consumed the weight of the fuel supply tank reduces, allowing calculation of fuel consumption. Data is transferred to the computer via serial port connection.

Additional data may be acquired from the engine with a Data Acquisition (DAQ) system. Generally several channels of temperature, pressure and etc. are logged and displayed on the computer. Data is transferred from the DAQ via USB.

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 then 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

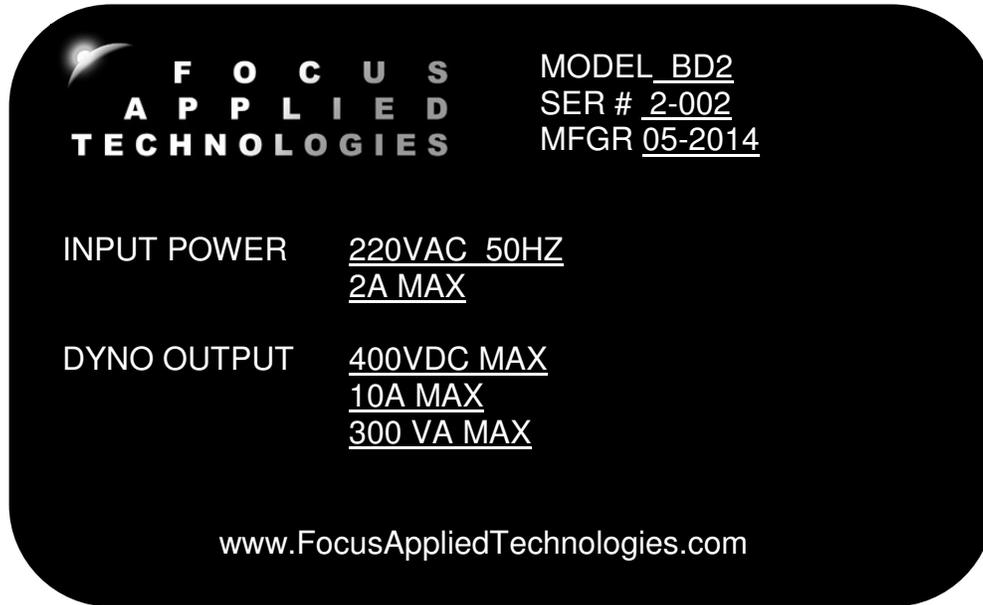
speed is calculated from period of **n** transitions, where **n** is the number of pulses per revolution. On the oscilloscope trace you should confirm that all **n** of the transitions exceed the threshold level, and none of the noise spikes do.

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 back to us any feed back you have regarding the use of this equipment.



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