

Power Stretcher for Electronic Fuel Injection Vehicles

Installation and Operation Manual

Rev 2.0 1-2017

Focus Applied Technologies

INTRODUCTION

To improve a vehicles performance engine modifications are common. On Fuel Injection vehicles the stock ECU can only compensate after some vehicle modifications as long as it does not exceed the preset limit (perhaps 5% variation in Volumetric Efficiency). Beyond that, re-tuning of the ECU is necessary to match the engine modification. However, tuning the stock ECU is not always an option because not all ECUs have such capability. One of the solutions is to install the "Power Stretcher" module.

The "Power Stretcher" is a piggyback fuel controller for electronic fuel injection vehicle, allowing the user to increase or decrease the amount of the fuel to the engine as a function of throttle position, engine speed and other variables (such as boost). It intercepts the stock fuel injection signal and then "stretches" its pulse width to drive the fuel injector, thus letting more fuel than the preset amount. Additionally the Power Stretcher can supply a "synthetic" Oxygen signal back to the stock ECU, allowing it to function normally even with Air/Fuel Ratio deviations from normal operation.

Any modification that requires significant fuel enrichment is an excellent reason to install the Fuel Stretcher such as:

- Bigger throttle body
- Intake manifold or exhaust pipe upgrade
- Engine cylinder bore enlargement
- Bigger intake valve
- Valve timing tuning
- Turbocharger or supercharger Installation



Warning

Good tuning of the Power Stretcher may improve the vehicle performance in term of power output. However, excessive tuning may lead to higher exhaust emission than permissible level that harmful to the environment and may violate the local laws. If you plan to use the Fuel Stretcher on the road, it is your responsibility to check with the local regulations to insure you are not in violation of any laws.

Requirement

The Power Stretcher can be installed in vehicles that use electronic fuel injection (EFI) as its fuel delivery system and it can supports up to 4-cylinder engines. It primarily requires access to fuel injection and throttle position signals. If the stock ECU comes with oxygen (O2) sensor, this signal must be intercepted in order to ensure the effectiveness of the Power Stretcher. Also for turbo/super charged vehicles a boost sensor is required for proper compensation.

Tuning

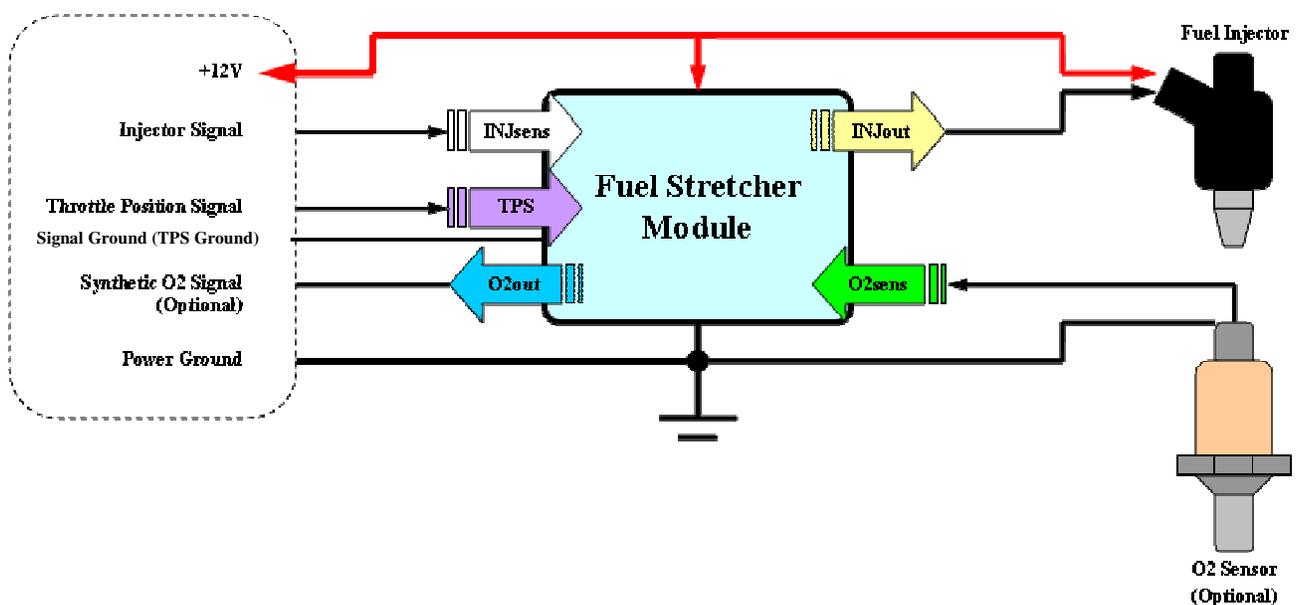
The setting and tuning are done via a Bluetooth-enabled computer or smartphone that support Serial Port Profile (SPP) capability, or with downloadable "Serial Communication" software for the Power Stretcher at www.FocusAppliedTechnologies.com downloads, software, Scm.

INSTALLATION

The installation of Power Stretcher is fairly straightforward. This module is powered by +12V and can be connected to +12V line of the fuel injector. The Ground (GND) line should be linked to the GND of the ECU which normally is the vehicle chassis. The installation of the Fuel Stretcher primarily need access to the fuel injection and throttle position sensor (TPS) signal lines. In the stock EFI system, the fuel injector is connected to +12V and fuel injector lines. The "Stretched" Injector signal (INJout) is connected directly to the injector and the injector sensing signal (INJsens) is connected to the outgoing injector signal of the stock ECU. The TPS line of Fuel Stretcher is shared with the stock ECU.

NOTE: If a "signal ground" is present (typically supplied to the TPS sensor) this should be connected to the Signal Ground of the fuel stretcher (if present) which is the thin black wire. The "Power Ground" of the fuel stretcher (thick black wire) can be connected to any good ground (ie. Frame ground, battery negative terminal, etc.). The signal ground is a clean ground line with low noise, whereas the power ground has significant electronic noise from the switching of the injector and other inductive loads. Separating the grounds reduces the electronic noise entering the stock ECU, improving smoothness and stability of the system. Many bikes do not have separate signal and ground lines, in which case the two ground lines from the fuel Stretcher should both be run to a frame ground.

IO/FROM STOCK ECU



For multi-cylinder engines the Injector sense line and Injector control (Inj out) are the same color (eg. Both are yellow). The thick wire is always the injector out line (as it carries the current from the injector), and the sense line is the thin wire.

FUEL STRETCHER
(1-cylinder)

FOCUS APPLIED TECHNOLOGIES

PERFORMANCE PRODUCT

Red	+12V (after +12V switch)
Blue (big)	Power GND (if present)
Black	Signal GND
Purple	TPS (throttle position sensor)
White	INJsens (from ECU)
Yellow (big)	INJout (to injector)
Blue	O2out (to ECU)
Green	O2sens (from O2 sensor)



FAT POWER

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FUEL STRETCHER
(2-cylinder)

FOCUS APPLIED TECHNOLOGIES

PERFORMANCE PRODUCT

Red	+12V (after +12V switch)
Blue (big)	Power GND (if present)
Black	Signal GND
Purple	TPS (throttle position sensor)
White	INJsens1 (from ECU)
Yellow (big)	INJout1 (to injector 1)
Orange	INJsens2 (from ECU)
Green (big)	INJout2 (injector 2)
Blue	O2out (to ECU)
Green	O2sens (from O2 sensor)



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Low cost EFI systems normally implement “open loop” fuel control which excludes O2 sensor. However, in more advanced EFI systems, precision air-fuel mixture control is achieved by the use of an O2 sensor. The installation of Fuel Stretcher on such system will be less effective if the stock ECU attempts to reduce the amount of fuel in order to compensate for the enriched air-fuel mixture. Therefore, this signal must be intercepted and Fuel Stretcher will replace it with a synthetic O2 signal to prevent the stock ECU from its compensating process. The signal line from the O2 sensor is connected to the O2 sensing line (O2sens) and the synthetic O2 signal (O2out) is connected to stock ECU. Under some conditions the Power Stretcher follows the actual O2 signal, allowing closed loop control by the stock EFI system.

SETUP AND TUNING

This version of the Power Stretcher integrates Bluetooth module for wireless serial communication. The setting and tuning of the Fuel Stretcher can be accessed through a Bluetooth-enabled computer or smartphone. When choosing Bluetooth dongle for a computer, it is important that for it to have Serial Port Profile (SPP) capability where it emulates a serial cable as to provide alternative to wired serial communication. The interface uses a simple text based system that can be accessed via a serial terminal program such as "Hyperterminal" and "RealTerm" for computer, and "Bluetooth spp pro" for Android smartphone. The serial communication parameters are configured as follow:

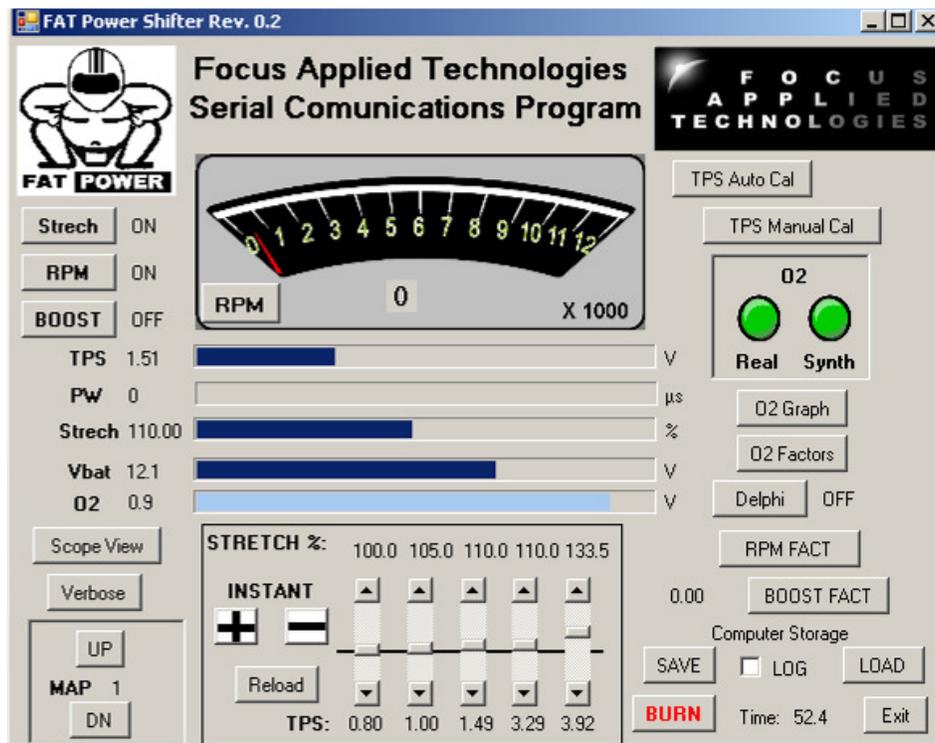
Baud: 9600
 Data Bits: 8
 Stop Bits: 1
 Parity: None
 Handshake: None

The easiest way to interface with the Power Strecher is to use the Power Strecher Serial Communications program Scom. It is a graphic interface allowing simple control over the unit, as well as calibrations of the various compensation factors, graphic display of the important parameters, as well as logging and back up of the maps and setup. It can be down loaded from at www.FocusAppliedTechnologies.com downloads, software, Scom.

When first running the software for the first time it will instruct you that the default values have not been set yet, and ask you to chose a serial communications port, displaying all available ports. If your computer has “native” serial communication ports (typically 9-pin “D” type connectors found at the back or side of desktop and lap top machines) these will be numbered 1 or 2. If you are using a serial cable and connecting directly to the corresponding 9-pin D connector available on non-blue tooth versions of the Power Strecher, you simply need a straight-through cable connecting pins 2, 3, and 5. If serial ports are not available, you may use a USB to serial port converter (we recommend “Sparkfun” units as they have better EMI immunity). These require a driver which can be downloaded from the manufacturer and must be

installed prior to use. When connected these USB-serial port adapters will appear as serial ports listed in the dialog box, and typically have a number from 3 to 30. If using a blue tooth unit, you'll need a blue tooth transducer connected to a serial port of the computer, or otherwise accessible to the software.

To begin communications to the Power Strecher, it must be connected properly to the appropriate lines on the vehicle, and powered on. You must first activate the "Verbose" mode, by clicking on the button on the lower left side of the screen. You may have to click it twice depending on the settings and history of the device. Once communications have been established the live display of TPS, RPM, Pulse Width, %Strech, Battery Voltage and O2 signal should be live. You can check this by opening the throttle and observing the TPS (Throttle Position Signal). It should display an increasing voltage and corresponding horizontal indicator bar.



Calibration should be done in the following order:

1) Calibrate Throttle (TPS)

Click the "TPS AutoCal" button (upper right). This will give you 5 seconds to open the throttle to the maximum position (WOT or Wide Open Throttle), and Idle (closed throttle). "Cal" will appear beside the button when in calibration mode. Once the 5 seconds have elapsed, the resulting TPS range will be divided up into 5 "bins" from idle to WOT. The bins are non spaced linearly, as air flow and fueling change rapidly with changes in TPS near idle, but they change relatively little near WOT. The bins will be displayed on the lower line of the "stretch" control box in the lower center of the screen. If you are not satisfied with these settings you can change them in the "Manual TPS Calibration" window accessed by the button of the same name.

2) Set up O2 Controls

Below the O2 display (right side) is a button "O2 Factors" which opens the Oxygen sensor controls shown below.

Set the O2 RICH TPS point to approximately 80% of the WOT TPS setting. Set the O2 Following voltage to about 0.1V above the Idle TPS reading. Below this TPS voltage the O2 signal will follow the actual O2 signal from the sensor, giving stable idling performance. Between these two TPS voltages the Power Shifter generates a synthetic "normal" O2 signal switching between ~0.1V and 0.8V. Above the Rich TPS voltage the O2 signal will be rich (~0.8V). After power on the O2 signal will be driven either high (Delphi brand O2

sensor mode) or low (non Delphi mode) for a period of time defined in the Warmup time. For Delphi this should be set to about 10 sec, and 30 sec for other systems.

Synthetic O2 Setup
Set the TPS thresholds for Synthetic O2 signal (Following, Synthetic, or RICH)

TPS
O2 goes RICH ABOVE:
Between these values O2 is synthetic
O2 follows signal BELOW:

Warmup Time (sec)

O2 signal simulates COLD sensor for this period of time after start.

Synthetic O2 Signal Characteristics

Low V	Switch Voltage	High V	Period	Duty Cycle
<input type="text" value="0.10"/>	<input type="text" value="0.51"/>	<input type="text" value="0.88"/>	<input type="text" value="1500"/>	<input type="text" value="50"/>
0.1 V	0.55 V	0.9 V	1000ms	50%

The numbers given are the recommended defaults.
Incorrect numbers may result in MIL triggering.

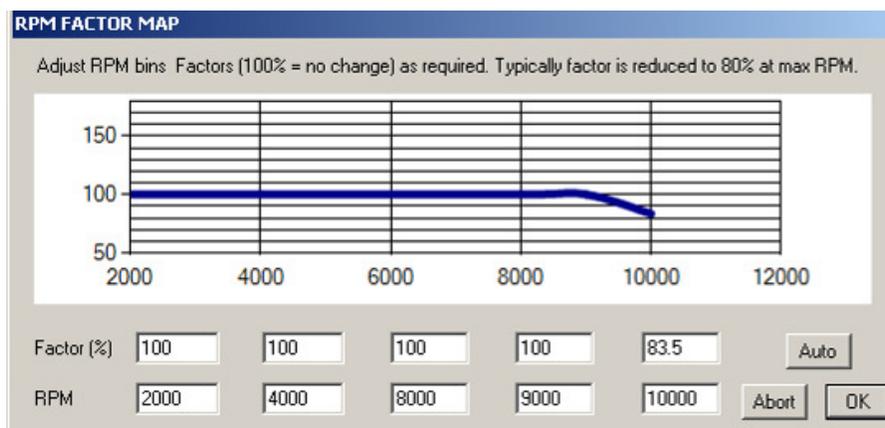
Auto
Abort
Exit

The Lower synthetic O2 voltage should be set to 0.1V, and the High voltage to about 0.8V. The switch voltage should be typically around 0.55V. The period and duty cycle of the synthetic O2 signal can also be set here. They should be about 1500ms, and 50% respectively. To save these changes to the Power Strecher, hit the OK button. To abort you're edits, hit the Abort button. To automatically calibrate the factors hit the Auto button.

Once you have set up the O2 parameters be sure to click the "Delphi" button on (if your vehicle used the small Delphi O2 sensor) or OFF for normal zirconia type O2 sensors.

3) Adjust the RPM Factors

Clicking on the "RPM Factors" button (lower right) opens the RPM Factor window. When opened it graphically shows the RPM fuel factor as a function of measured RPM. Typically this will be set to 100% (ie. No change in fuel) over most of the speed range. If the additional fuel provided by the main Power Stretch at WOT is too much for high speed operations (this typically happens due to a drop in air flow at very high engine speeds), then the fueling can be reduced at higher speeds. To return the system to normal fueling at maximum throttle and speed the right most (ie. Fastest) factor should be the reciprocal of the WOT fuel stretch, ie. If the WOT fueling is set to 120%, then the highest RPM factor should be 1 / 1.2 or about 83%. The next to last RPM bin should be set as low as necessary to prevent underfueling at lower speeds. For example if the engine's "red line" (maximum speed) is 10,000 rpm, and we want to reduce fueling by 20% at 10,000 rpm to compensate for a 125% fueling factor at WOT, then the 10,000 rpm factor might be 80%. This could begin by tapering to 90% at 8000. As shown in the graph fueling would actually start being reduced from 7000 rpm onwards. To move this "taper" to higher speeds, just change the speed of the last few rpm bins. The RPM Factor is applied at ALL throttles, and can be used to increase or decrease fueling. If using oversized injectors, you can use a constant factor of less than 100% at all speeds.



4) Boost Factor

Similar to the RPM Factor, there is a fuel factor which is a function of Boost (or any other analog input, such as Temperature for example). The setup is similar to the RPM Factor.

5) Fueling Stretch

The main fueling map is shown in the lower center of the screen. The TPS bins (bottom line) should match the already defined TPS bins. The top row (Stretch%) are the main fueling factors. These numbers should generally be ~100 to 120%, but this depends on modifications made to the vehicle. Generally the idle fueling is left at 100% as the native EFI system will be in "closed loop O2 control", and remove any additional fuel. For improved drivability a factor of 105 to 110% is reasonable, but at WOT this may have to be reduced to 100-105%, as the native system usually already richens up the fueling at WOT sufficiently.

If major modifications have been made, then the fueling factors need to reflect the expected changes in airflow. For example if the intake path, throttle body and valve timing has been modified with an expected 20% increase in air flow, then the factors might need to be set to 110 at idle to perhaps 140% near WOT.

6) Final Setup and Burning to memory

There are several additional controls, such as the buttons at the upper left allowing individual toggling of Stretch, RPM and Boost ON/OFF. When the Stretch switch of OFF, then NONE of the stretch factors are used, and essentially the unit is in a "bypass" mode. There is a "Map Select" box in the lower left. This allows selection of any of 3 different main stretch maps. Typically Map 1 would be set up with minimum fueling, Map 2 would have more (say 5% additional) fueling, while the 3rd map might be even more aggressive. This will allow for quick verification of different maps, or different "modes" such as economy (maps with minimal fueling) and performance (maps with maximum fueling). NOTE: Each fueling map needs to be burned independently. First select that map in the Map Select box, then hit the BURN button.

Once the initial setup is complete, click the "BURN" button to save the configuration to non-volatile memory. These configurations will still be present after power down. Any edits you make will be lost unless you hit the BURN button before powering off the unit.

NOTE: The engine may misfire or even stall when burning the setup to memory as the burn takes priority over operating the injectors.

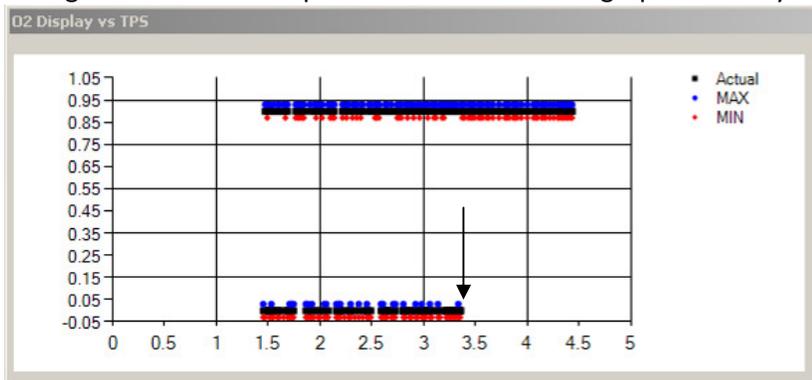
7) Tuning

Every vehicle will require different tuning unless they are identical. Even with the same model sometimes there are slight variations in things like the Idle TPS setting, and injector characteristics. Therefore it is advisable to do some final tuning on each vehicle modified with the Power Strecher. Tuning consists of verifying the various settings effect on the vehicle. The ideal way to tune is using an Air/Fuel Ratio (AFR) meter measuring the exhaust gas on a Chassis dynamometer, or on a road track. The Stretch value can then be increased/decreased as required to achieve the target AFR. While in operation the fueling can instantly be increased or decreased by hitting the large "+" and "-" buttons on in the fuel stretch box. This will adjust the fueling by ½% at the current TPS bin. Alternatively the individual TPS bins can be increased/decreased by manipulating the appropriate sliders in the box.

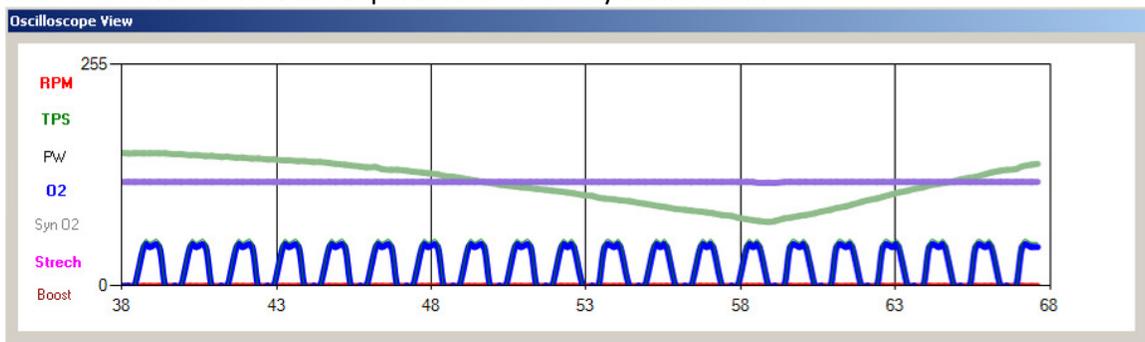
Each map should be tuned for the performance required of that map or mode. The RPM factor should be adjusted for proper fueling as a function of engine speed. The Boost map should be tuned similarly for proper boost compensation.

Oxygen sensor performance can be monitored with the red (lean) and green (rich) indicator lamps on the right. At intermediate throttles the Synthetic O2 signal should "blink" consistently, and the Real O2 signal should be GREEN (ie. Rich). At low throttles (ie. Idle) they should both follow the actual exhaust gas O2 slowly drifting back and forth from rich to lean. Near WOT both should go rich.

An O2 sensor graph is supplied to help investigate the actual upper. O2 control limit. To use this shut off the O2 synthetic signal by making the O2 Following voltage equal to the WOT throttle voltage. As the vehicle operates the actual O2 sensor voltage (and rich and lean limits) are displayed in the graph accessible via the O2 graph button. Above the native systems upper O2 control limit the Minimum O2 voltage will be rich. This point is identified in the graph below by the arrow.

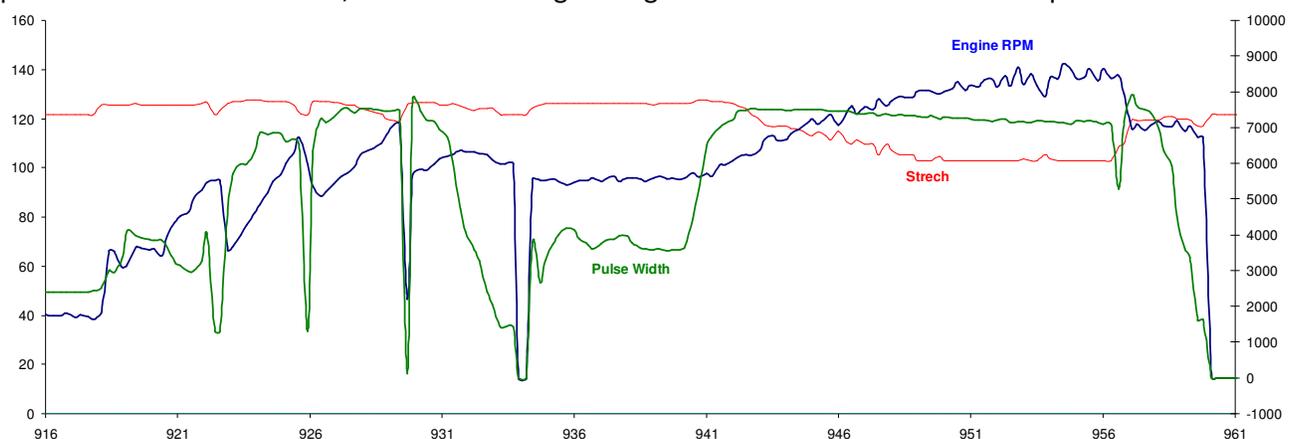


Additionally an "oscilloscope view" is displayed when the "Scope view" button is clicked. This shows the last 30 seconds of the various parameters for easy verification.



Similarly all the important parameters can be logged to a file while in operation by ticking the "LOG" check box. This will ask for a file name, and then stream data from the Power Strecher continuously into the file. If a wide band O2 sensor (AFR sensor) is used, it can be read simultaneously for off line "auto tuning".

The data below shows a launch and high speed operation, indicating a decrease in the WOT fueling with speed due to the RPM Factor, which is reducing fueling back down to ~100% at 8000+ rpm.



Finally, the current fuel strecher setup can be saved (in byte form) to a file by clicking the "SAVE" button.

When tuning it is best to start with small fueling increments and test out every step carefully. When you have a map you are happy with, be sure to burn it to memory, and save it to a file for future reference.

APPENDIX 1

COMUNICATIONS PROTOCOL

Communications: RS-232
Baud: 9600
Bits: 8
Data Transfer: Binary

Several “toggles” are provided for quick manipulation of the Power Stretcher’s functioning. These are sent as a single byte, and elicit no direct response from the Stretcher (however the appropriate status bits of the status bytes will be effected).

Character	Action
V/v	Turns verbose mode ON/OFF (ie. Sending a “V” turns verbose mode ON)
S/s	Turns Stretch mode ON/OFF (ie. Sending a “s” turns Stretch OFF)
O/o	Turns O2 control ON/OFF (in off mode the signal is sent directly to the ECU)
M/m	Increment/Decrement Map number (rolls over at 1 and 3)
B/b	Boost ON/OFF
R/r	RPM Factor On/OFF
P/p	Delphi (ie. Current pump) ON/OFF
K/k	RPM Speed Factor INcrease/DEcrease
+/-	Increase/Decrease fueling at current Stretch Map TPS bin

There are a few “single character” commands for control:

Character	Action
A	Requests single PING (response explained below)
G	Guard (burn) current map and calibrations to memory

Standard data ping from Power Stretcher:

Z	Synchronization Character
RPM high	High byte of engine speed
RPM low	Low Byte of engine speed
TPS	Throttle position
PW high	High Byte of Pulse Width (in μ s)
PW low	Low Byte of Pulse Width (in μ s)
O2	O2 Signal voltage
O2 Status	Oxygen Status Byte
Vbat	Battery Voltage
MapStat	Map Status Byte
Temp	Temperature Sensor Voltage
Boost	Boost channel Voltage
RES1	Internal Clock Count
RES2	Wideband O2
RES3	Unused
RES4	Unused

Finally there are several map manipulation commands. These can either query/change an individual map element, or a whole map.

Command	Action
Dx	Dumps map x (where x is the number 0 to 16 in byte form) Response is 5 bytes: Map x element 1, 2, 3, 4, 5
Exy	Enumerate Map x Element y (x is 0 to 16, y is 1 to 5 both in byte form) Response is 1 byte: Map x Element y
Fxy#	Forced Write of # to Map x Element y (ie. Put # into map x at position y, all in byte form) This command returns no response
Lxabcde	Load Map x with a, b, c, d, e in elements 1-5 respectively (all in byte form) This command returns no response

O2 Status Byte Explanation:

O2 Stat:		BITS							
		7	6	5	4	3	2	1	0
High	O2 Out			Stat-Hi	Ocil-Dir	Norm	Rich	Follow	Delphi
Low	O2 Out			Stat-Low	Static	Direct	Click	Synthetic	Std
						CNTL		Output	

MAP Status Byte Explanation:

Map Byte:		BITS							
		7	6	5	4	3	2	1	0
High	Boost Com	RPM Com	Shift ON	RPMfact.1	RPMfact.0	Map.2	Map.1	Map.0	
Low	Boost Off	RPM Off	Shift OFF						

The number of the current fuel stretch map is contained in the first 3 bits.

Various Maps Explanation:

X	Y					
	1	2	3	4	5	
"MAP" #	TPS					
0	50	70	100	150	220	
1	100	102	105	110	110	Factor (1/2% Precision)
2	102	105	110	115	115	Factor (1/2% Precision)
3	102	105	110	115	120	Factor (1/2% Precision)
...						
10	TPS_idle	TPS_rich	TPS_wot	twarmup		
11	O2_low	O2_high	O2_period	O2_duty	O2_sv	
12	20	40	60	100	120	100's
13	100	100	100	90	70	Factor (1/2% Precision)
14	50	100	150	200	250	ADC
15	110	120	130	140	150	Factor (1% Precision)

Map 0 is the 5 TPS bins (0-255 is 0-5V)

Maps 1-3 are the fuel stretch maps 1-3 respectively

Map 10 is the various TPS levels for O2 control, and warmup time

Map 11 is the various O2 voltage levels, period, duty cycle (in %) and switching voltage

Map 12 is the RPM bins (for RPM compensation)

Map 13 is the RPM factors

Map 14 is the Boost Voltage bins (0-255 is 0-5V)

Map 15 is the Boost Factors

NOTE: Maps 1-3, and 13 are in ½ % precision, starting at 50%. I.e. A “0” means the factor is 50%, a “100” means the factor is 100%, and a “200” means the factor is 150%.

Map 15 is in single% precision from 0 to 255%

Voltages are in byte form 0-255 being 0-5V