V2 | N2 2020

Ford Tech Tips

Technical Knowledge for Ford Service Professionals

FORD **PARTS**

Turbocharger & Supercharger Diagnostics

Naturally aspirated engines found in today's vehicles can be classified as highly volumetric efficient due to advancements in engine design and engine controls. Many of these advanced features have been appearing over the years. Examples are variable length intake runners, variable camshaft timing, cylinder head design and so on. The overall goal is to make the engine as volumetric efficient as possible across a wide operating engine RPM range. For review, volumetric efficiency (VE) is the measurement of the engine's ability to pump its displacement. For example, say you have a two-liter engine. If that engine were able to achieve 100 percent VE it would be able to move two liters of air in and out of the engine while at a certain RPM. This RPM would also correlate with the point at which the engine produces the maximum amount of torque. Some modern, naturally aspirated engines can come close to 100 percent efficient, but it's rare. An excellent engine design would offer a volumetric efficiency beginning at very low engine speeds, up to near redline. To make more torque, all one would need to do is build a bigger engine.

Power to weight ratio

Vehicle efficiency is measured by looking at the energy required to move its mass. If the mass can be reduced and power increased, this is a win. This is one of the primary reasons turbochargers and superchargers are becoming more commonplace on today's internal combustion engines. If an engine manufacturer can get the same performance out of a 2.3L engine that a 4.0L or more can produce, then this is a win.

Turbochargers

Turbochargers use the hot, expanding gas exiting the exhaust port to spin a turbine within the turbocharger housing. This turbine wheel in turn drives a shaft with a similar turbine on the other side that is used to pull air into the inlet housing, compress it and send it out to the engine. Basically, the turbocharger is tasked with force-feeding the engine more air mass than it could otherwise ingest in a naturally aspirated environment. Oftentimes, a production engine and turbocharger design can result in an engine capable of doubling its air mass. This results in more power from less mechanical mass. When air is compressed, it builds heat. Hot air is less dense, which results in less power than what cooler, much denser air would produce. This is why we have heat exchangers (intercoolers) tasked with extracting heat from this newly compressed air. These heat exchangers are usually found up in front of the vehicle and could be above, below, or in front of the radiator. A series of special high-pressure hoses and tubing connect the cooler to the turbo and the throttle body. The air exiting the intercooler is usually measured for pressure and temperature so the PCM can assess the cylinder air charge, allowing for the proper fuel and spark timing commands. On the other side of the throttle body, (somewhere in the intake manifold) there will be another measurement device sampling pressure and temperature that the PCM will also factor in the above-mentioned commands.

Modern turbocharger air flow production is PCM controlled. In addition to all the normal PCM controls found on naturally aspirated engines, the PCM is tasked with controlling the following additional items:

- Wastegate – used to control how much exhaust gas is used to drive the turbine controlling turbo speed. (Could be either electronically controlled pneumatic solenoids or a stepper motor device.)
- Bypass Valve – used to dump turbo pressure when the throttle plate is suddenly closed (usually a pneumatic solenoid device).

Superchargers

Superchargers work similarly to turbochargers by force-feeding the engine with air, but the energy to drive it comes from the crankshaft. The beauty of the supercharger is that the available pressure isn't delayed as it is with a turbocharger waiting for the exhaust pressure to spin up the turbo to begin compressing air. Many of the same controls are used to manage airflow and pressure.

Sensors

As one would expect, when you supercharge/turbocharge your engine design, the PCM will need a number of additional data inputs. As mentioned earlier, one of those inputs reflects the pressure and temperature of the air exiting the intercooler (TCB-A) as well as the pressure inside of the intake manifold (MAP). While we're talking pressure, we need a sensor that can measure both negative and positive pressures. The positive pressures we typically see on turbocharged or supercharged applications may reach as high as approximately 200 kPa absolute (15 psi). Since we have two pressure sensors on the engine, they both should be within 9.2 kPa (2.72 in. Hg) of each other during a key on engine off (KOEO) evaluation. Most late model Ford Motor Company vehicles also have a barometric pressure sensor (BARO) mounted inside the ECM. This measurement is used to crosscheck TCB-A and MAP during initial vehicle power up events just before engine start. The BARO/MAP readings should be within 6.86 kPa (2.03 in. Hg) of each other KOEO, and the TCB-A/BARO should be within 7.25 kPa (2.14 in. Hg). It is essential that the PCM know the atmospheric pressure conditions at all times. All these inputs are necessary so that the PCM can provide the optimal fuel rate and spark advance at any given moment.

Controls

Back in the day of early turbochargers, boost control was a simple operation where a pneumatic air hose was connected between the supercharger outlet and the wastegate actuator. This actuator consisted of a spring-loaded wastegate diaphragm calibrated to begin opening at a specific positive pressure. When the boost pressure exceeded that calibrated point, the air pressure would overcome the spring pressure and begin to lift the wastegate actuator valve off its seat, reducing the exhaust pressure driving the turbocharger. On a pneumatic solenoid system, when the solenoid is off, it is free-flowing (open) and allows full outlet pressure to be applied to the wastegate actuator thus limiting overall boost to about 34 kPa (5.0 psi). When fully engergized, the solenoid will not pass any pressure to the wastegate, allowing for maximum pressure. Today, these systems require much more refined controls. Although some use the pressure-bleed system via a pneumatic solenoid, other vehicles utilize a vacuum pump supported by a reservoir system in order to operate the wastegate with more precise control. This is typically found in applications where turbocharger control is used during light loads to reduce the engine pumping losses. Later model systems are now using an H-Bridge stepper motor control for even more accuracy as shown in Figure 1. One can find a wealth of information on how these systems work in the Ford OBD Operational Summary documents found on the MotorcraftService.com website.

Calibrations

Internal to the ECM, you will find a number of new calibrations needed so that the system can understand the dynamics and control them accurately. Some of the typical calibration functions internal to the ECM include:

- Intake manifold volume
- Intercooler volume
- Compressor efficiency map
- Bypass valve opening/closing time delay
- Pressure limits
- Airflow limits
- Expected throttle inlet pressure (TIP)

The Turbo Flow (grams/sec) table below, shows some of those calibration functions.

Figure 1: Turbocharger H-Bridge Wastegate

Turbo Flow (grams/sec)

RPM	22.7	34	45.4	52.9	64.3	75.6	90.7	105.8	151.2	211.7
80K	33.9	44	57.6	67.7	847	101.6	118.5	135.5	169.3	203.2
100K	47.4	61	84.7	101.6	135.5	152.4	135.5	169.3	196.4	220.1
110K	61	74.5	101.6	135.5	108.4	135.5	152.4	186.3	220.1	220.1
120K	67.7	94.8	128.7	152.4	152.4	152.4	169.3	186.3	220.1	220.1
130K	101.6	152.4	152.4	152.4	152.4	152.4	169.3	186.3	220.1	220.1
140K	152.4	152.4	152.4	152.4	152.4	152.4	169.3	186.3	220.1	220.1
150K	152.4	152.4	152.4	152.4	152.4	152.4	169.3	186.3	220.1	220.1
160K	152.4	152.4	152.4	152.4	152.4	152.4	169.3	186.3	220.1	220.1
170K	152.4	152.4	152.4	152.4	152.4	152.4	169.3	186.3	220.1	220.1
180K	152.4	152.4	152.4	152.4	152.4	152.4	169.3	186.3	220.1	220.1

Turbo Expected Throttle Inlet Pressure based on inferred airflow and turbo RPM (Y Axis = Turbo RPM)

Desired Throttle Inlet Pressure (TIP) 0% DC	
Airflow (grams/sec)	**Desired TIP (kPa)**
0	0
38	1.5
76	4.4
113	6.8
151	8.7
189	10
227	10.8

Turbo Desired TIP @ Wastegate 0% Duty Cycle

Desired Throttle Inlet Pressure (TIP) 100% DC	
Airflow (grams/sec)	**Desired TIP (kPa)**
0	203.2
7.6	203.2
15.1	203.2
22.7	203.2
32.1	203.2
37.8	203.2
75.6	203.2
102.1	203.2

Turbo Desired TIP @ Wastegate 100% Duty Cycle

Engine Speed vs. Turbo Air Charge Temp (grams/sec)				
ACT	-6.7 C	25 C	37.8 C	65.6 C
500	294	250	243	216
1000	294	250	243	216
2000	294	250	243	216
3000	313	101	263	234
4000	349	136	294	261
5000	346	152	288	251
6000	344	136	287	248
6500	371	169	316	277
7000	371	196	316	277

Turbo Airflow Limit in grams/sec

Turbocharger control

Maintaining tight control over the turbocharger is essential for driveability and emissions/fuel economy. The PCM's boost control system calculates the amount of desired boost at any given conditions and achieves the desired amount through its wastegate controls as mentioned earlier. Cylinder air charge control is regulated by use of the throttle plate so that the engine is receiving the right amount of air. Figure 2 demonstrates how the throttle plate is manipulated during a WOT acceleration. The Accelerator Pedal Position (APP) remains at 100 percent in the period shown in the datalog. Looking at the cursor and the second and

Name	Value
Engine RPM	3,583 rpm
Boost Pressure	104 kPa
Throttle Inlet Pressure Actual	198 kPa
Throttle Inlet Pressure Desired	204 kPa
Injector Pulse Width	0.0 ms
DI Start Of Injection Angle (Intake)	0.0 °
DI End Of Injection Angle (Compression)	0.0 °
Vehicle Speed	25 km/h
Engine Coolant Temp	94 °C
Intake Air Temp	21 °C
Manifold Absolute Pressure	199 kPa
Timing Advance	1.5 °
Knock Retard	-0.3 °
Accelerator Pedal Position	100.0 %
Throttle Position	100.0 %
Relative Throttle Position (SAE)	80.4 %
Commanded Throttle Actuator (SAE)	100.0 %
Equivalence Ratio Commanded (SAE)	0.854 λ
WB EQ Ratio Bank 1	0.98 λ
Fuel System #1 Status (SAE)	CL - Normal
Short Term Fuel Trim Bank 1	-2.3 %
Long Term Fuel Trim Bank 1	7.0 %
Fuel Rail Pressure Desired	22.771 MPa
Fuel Rail Pressure (SAE)	24.190 MPa
Fuel Level Input (SAE)	100.0 %
Control Module Voltage	13.04 V
Absolute Load (SAE)	162.4 %
Barometric Pressure	94 kPa

Figure 2: Throttle Control for Air Charge

third row of data, you can watch the PCM take the throttle from 100 percent down to approximately 50 percent, and see the effect it had on MAP and the throttle inlet pressure (TIP) desired vs. actual.

Another condition the PCM needs to handle is compressor surge. This occurs when the throttle is rapidly closed while the system is in boost pressure mode, which in turn can cause excessive loads against the compressor turbine. The PCM controls this through the use of a bypass solenoid (Figure 3) by recycling the pressure from the turbocharger outlet back to the compressor inlet.

Throttle control

Vehicles today use "throttle by wire" systems. These systems typically include a throttle pedal assembly containing an APP sensor. The APP sensor has two potentiometers with two different positive slopes. The APP assembly will have a total of six wires, two 5V reference signals, two signal returns and two throttle pedal position signals. The throttle body (Figure 4) will usually have eight circuits where two are for the bi-directional throttle motor. The remaining wires support two potentiometers for the throttle position sensors. Both of these sensors, however, have opposite slopes — one increasing in voltage and the other decreasing. These two sensors also have their own 5V reference, signal returns and output signal circuits. As a diagnostic tip, when you have opposite slopes, the sum of the two outputs should always stay the same. So, if you were to measure the differential with a scope you should see a flat line somewhere between 0-5V and it shouldn't change as you cycled the throttle from closed to open. If the signal blips, then you've discovered your problem.

Figure 3: Turbocharger Bypass Valve

Digital Communication Sensors

Late model Ford vehicles are now using a serial data line (single wire) to communicate with the PCM. The data communication protocol is called Single Edge Nibble Transmission (SENT). This is a one-way, point-to-point communication signal used to report sensor status to a controller such as the PCM. The official SAE Standard is J2716. In the future, you'll likely see more sensors using this protocol. If you're interested in what this signal looks like and how you can decode transmission data, you'll want to check out PicoScope®. They have included a number of serial decoding tools within their application. Figure 5 shows a signal acquired from a 2020 Ford Ranger. This protocol allows for multiple messages about the sensor to be transmitted to the controller. Most of your diagnostics are going to be carried out from within the scantool. However, the PicoScope application may prove to be a useful tool in ascertaining a higher level of knowledge and awareness of the overall sensor's state of health.

Diagnostics

When addressing any turbocharger-related complaint, it's always a good idea to perform a full vehicle scan so you can see if there are any other modules on the network reporting trouble that could be relevant to the task at hand. Figure 6 shows the result of a system scan within FDRS from a 2020 Ford Ranger.

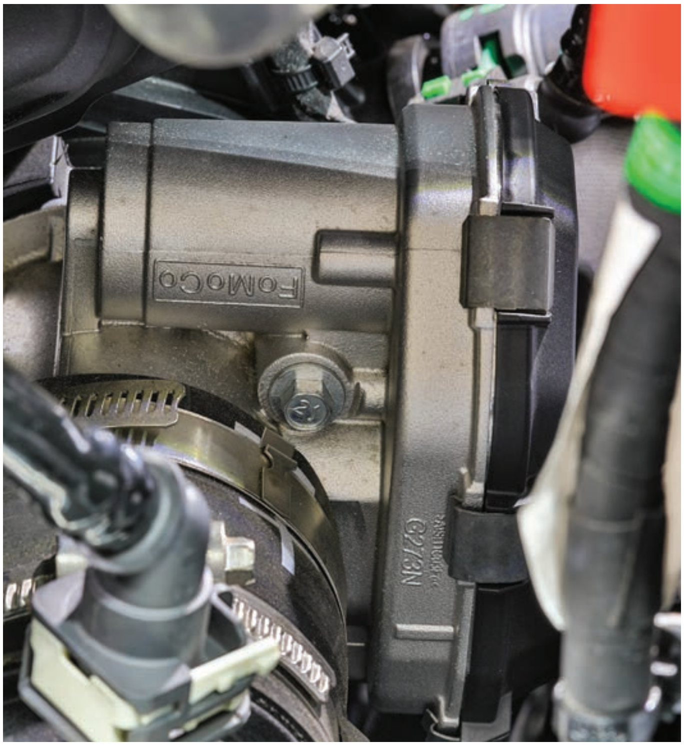
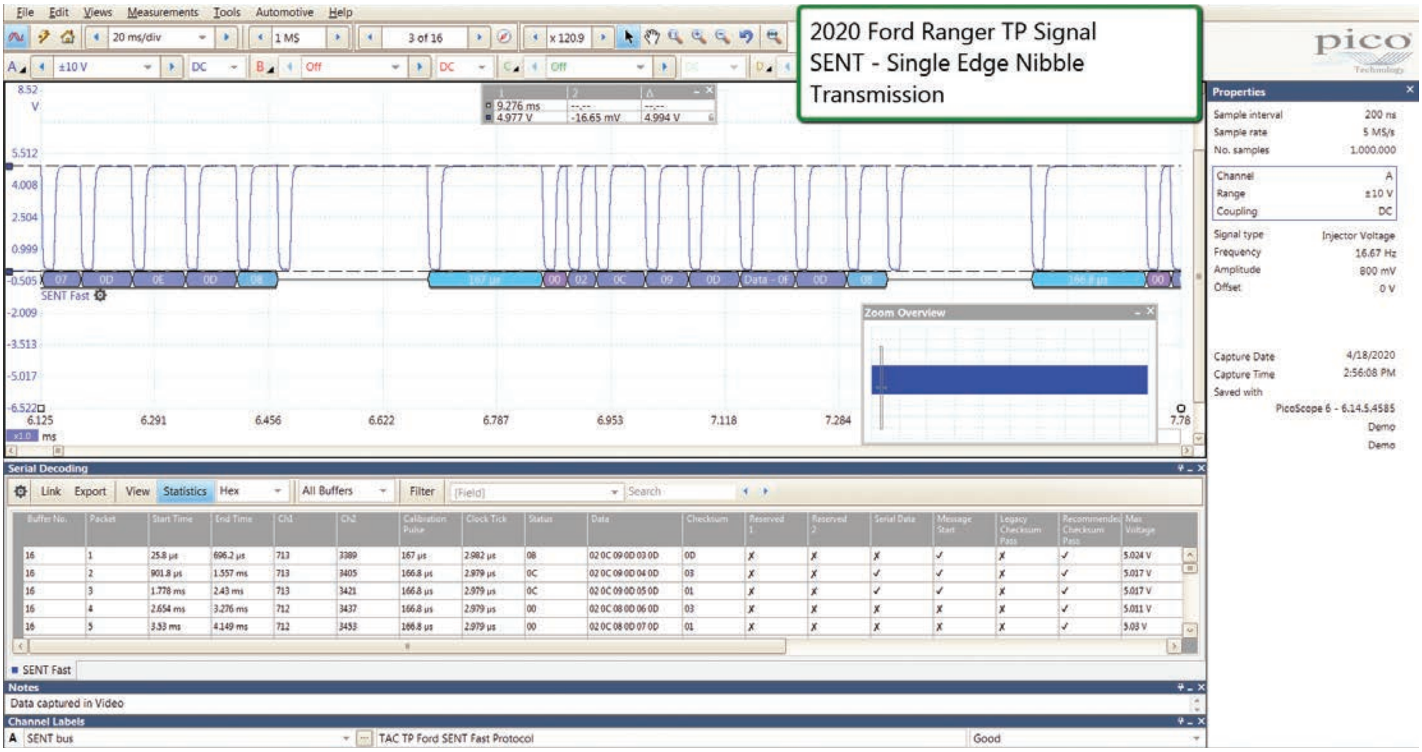


Figure 4: Throttle Body

If you're in a situation where you have a no-code driveability complaint, you'll want to leverage the power of the scan tool in order to look for clues that will help you establish operational conditions. With FDRS you'll find a plethora of diagnostic aids that can help you test and rule out areas of suspicion. FDRS is a cloud-based tool, meaning that most of the tools and utilities needed will usually be the latest and greatest. Before you begin scanning with FDRS, it is recommended that you study the user settings page



2020 Ford Ranger TP Signal
SENT - Single Edge Nibble Transmission

Properties
Sample interval: 200 ns
Sample rate: 5 MS/s
No. samples: 1,000,000
Channel: A
Range: ±10 V
Coupling: DC
Signal type: Injector Voltage
Frequency: 16.67 Hz
Amplitude: 800 mV
Offset: 0 V
Capture Date: 4/18/2020
Capture Time: 2:56:08 PM
Saved with: PicoScope 6 - 6.14.5.4585 Demo Demo

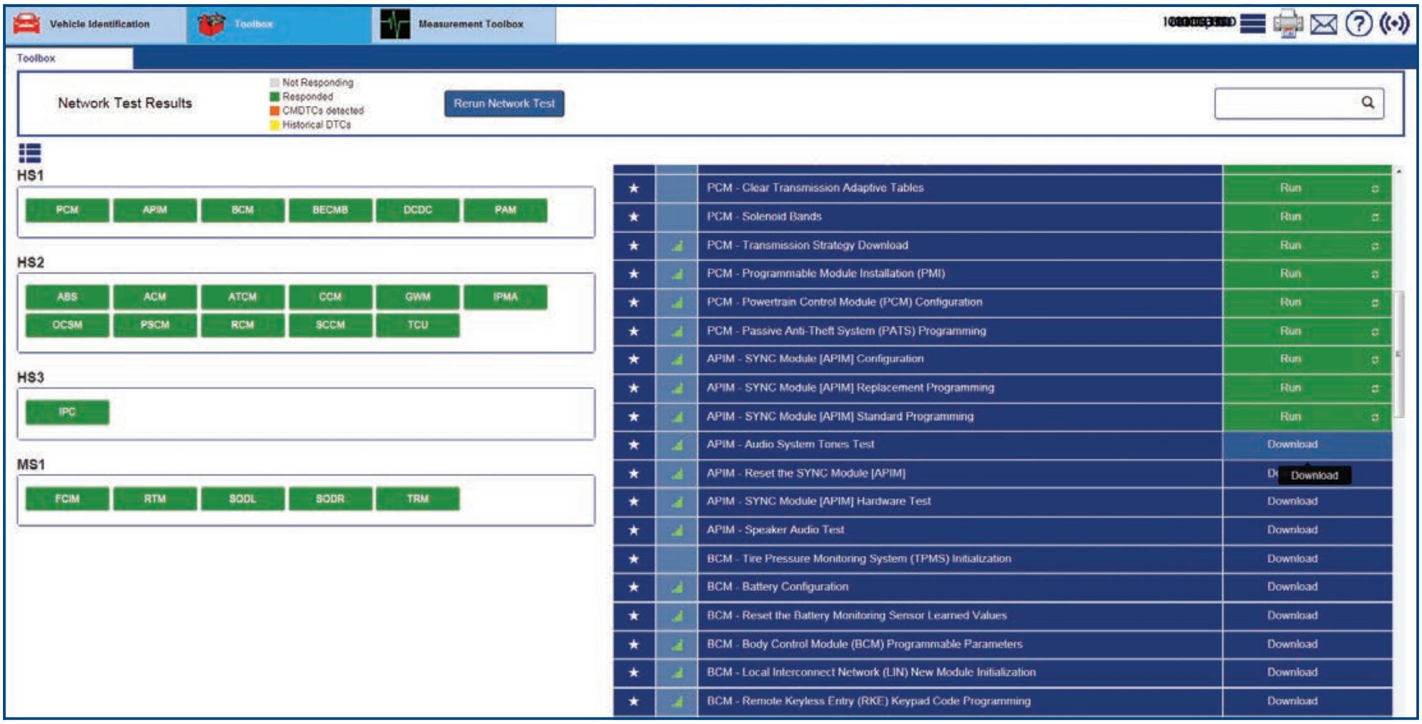
Serial Decoding

Buffer No.	Packet	Start Time	End Time	Ch1	Ch2	Calibration Pulse	Clock Tick	Status	Data	Checksum	Reserved 1	Reserved 2	Serial Data	Message Start	Legacy Checksum Pass	Recommended Checksum Pass	Max Voltage
16	1	25.8 µs	696.2 µs	713	3389	167 µs	2.982 µs	08	02 0C 09 0D 03 0D	0D	✗	✗	✗	✓	✗	✓	5.024 V
16	2	901.8 µs	1.557 ms	713	3405	166.8 µs	2.979 µs	0C	02 0C 09 0D 04 0D	03	✗	✗	✓	✓	✗	✓	5.017 V
16	3	1.778 ms	2.43 ms	713	3421	166.8 µs	2.979 µs	0C	02 0C 09 0D 05 0D	01	✗	✗	✓	✓	✗	✓	5.017 V
16	4	2.654 ms	3.276 ms	712	3437	166.8 µs	2.979 µs	00	02 0C 08 0D 06 0D	03	✗	✗	✗	✗	✗	✓	5.011 V
16	5	3.53 ms	4.149 ms	712	3453	166.8 µs	2.979 µs	00	02 0C 08 0D 07 0D	01	✗	✗	✗	✗	✗	✓	5.03 V

Notes: Data captured in Video

Channel Labels: A SENT bus — TAC TP Ford SENT Fast Protocol — Good

Figure 5: SENT TP Signal



Network Test Results

- Not Responding
- 🟩 Responded
- 🟧 CMDTCs detected
- 🟨 Historical DTCs

HS1: PCM, APIM, BCM, BECMB, DCDC, PAM

HS2: ABS, ACM, ATCM, CCM, GWM, IPMA, OCSM, PSCM, RCM, SCCM, TCU

HS3: IPC

MS1: FCIM, RTM, SODL, SODR, TRM

★	PCM - Clear Transmission Adaptive Tables	Run
★	PCM - Solenoid Bands	Run
★	PCM - Transmission Strategy Download	Run
★	PCM - Programmable Module Installation (PMI)	Run
★	PCM - Powertrain Control Module (PCM) Configuration	Run
★	PCM - Passive Anti-Theft System (PATS) Programming	Run
★	APIM - SYNC Module [APIM] Configuration	Run
★	APIM - SYNC Module [APIM] Replacement Programming	Run
★	APIM - SYNC Module [APIM] Standard Programming	Run
★	APIM - Audio System Tones Test	Download
★	APIM - Reset the SYNC Module [APIM]	Download
★	APIM - SYNC Module [APIM] Hardware Test	Download
★	APIM - Speaker Audio Test	Download
★	BCM - Tire Pressure Monitoring System (TPMS) Initialization	Download
★	BCM - Battery Configuration	Download
★	BCM - Reset the Battery Monitoring Sensor Learned Values	Download
★	BCM - Body Control Module (BCM) Programmable Parameters	Download
★	BCM - Local Interconnect Network (LIN) New Module Initialization	Download
★	BCM - Remote Keyless Entry (RKE) Keypad Code Programming	Download

Figure 6: Full Scan – Ford FDRS

and set up the unit measurement system in the units you're most comfortable with. See Figure 7.

Here are a few useful routines to look for in FDRS:

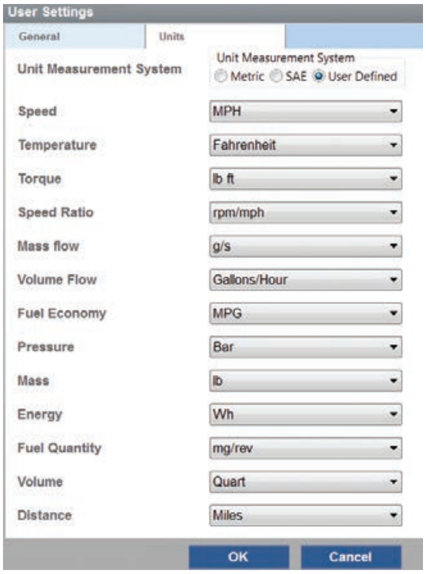
Fuel supply tests

As shown in Figure 8, this test will perform a pressure and timed leak down test of the low pressure in-tank fuel pump.

Direct injection tests can be performed through the engine running fuel pressure test as shown in Figure 9.

Fuel trim

Fuel trim is one of the most powerful feedback tools a technician should be leveraging today. Logging both short- and long-term fuel trim throughout various loads can be a very good indicator of how the system is doing in regard to predicting cylinder air charge and fuel delivery. If the LT+ST FT exceed 15-25 percent, suspect an issue. Most fuel trim DTC's won't code until the sum exceeds +/-30 percent or higher for most vehicles.

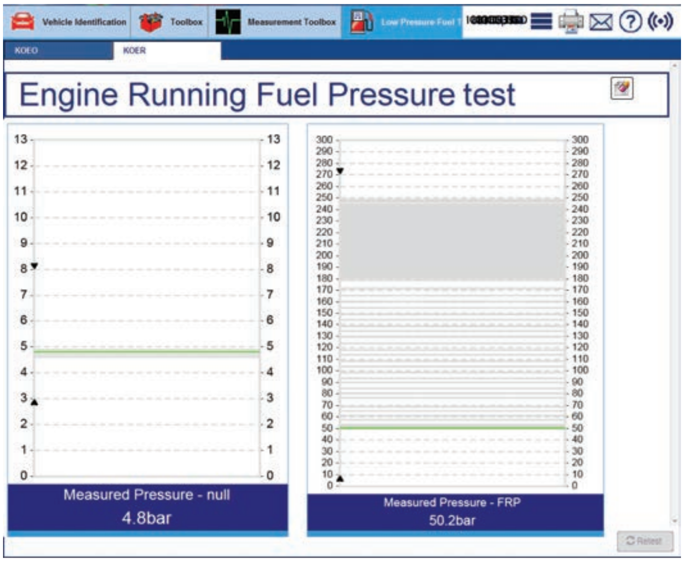


Unit Measurement System	Unit Measurement System ○ Metric ○ SAE ● User Defined
Speed	MPH
Temperature	Fahrenheit
Torque	lb ft
Speed Ratio	rpm/mph
Mass flow	g/s
Volume Flow	Gallons/Hour
Fuel Economy	MPG
Pressure	Bar
Mass	lb
Energy	Wh
Fuel Quantity	mg/rev
Volume	Quart
Distance	Miles

Figure 7: User defined values

Lambda

Road testing the vehicle while monitoring commanded EQ Ratio vs Actual EQ Ratio can be an eye-opener. Preferably one may want to collect several parameters and record a road test so that the data can be reviewed back at the shop. FDRS can make this task quite daunting so you may want to take a look at your personal scan tool assets and see what they offer for recording. Figure 10 is a data set recorded on a 2020 Ford Ranger

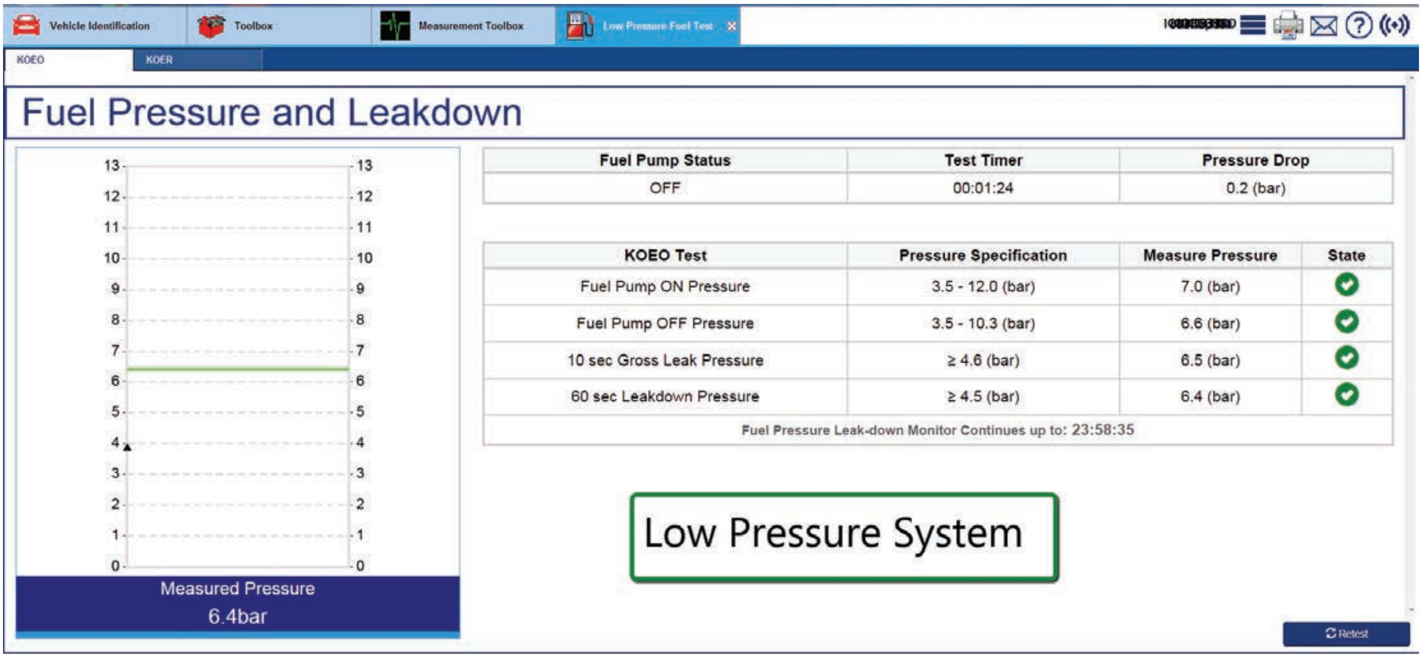


Engine Running Fuel Pressure test

Measured Pressure - null
4.8bar

Measured Pressure - FRP
50.2bar

Figure 9: Engine Running DI Fuel Pressure test



Fuel Pressure and Leakdown

Measured Pressure
6.4bar

Fuel Pump Status	Test Timer	Pressure Drop
OFF	00:01:24	0.2 (bar)

KOEO Test	Pressure Specification	Measure Pressure	State
Fuel Pump ON Pressure	3.5 - 12.0 (bar)	7.0 (bar)	✓
Fuel Pump OFF Pressure	3.5 - 10.3 (bar)	6.6 (bar)	✓
10 sec Gross Leak Pressure	≥ 4.6 (bar)	6.5 (bar)	✓
60 sec Leakdown Pressure	≥ 4.5 (bar)	6.4 (bar)	✓

Fuel Pressure Leak-down Monitor Continues up to: 23:58:35

Low Pressure System

Figure 8: Low Pressure Fuel Pump tests

2020 Ford Ranger 2.3L Turbo DI
WOT Tests

Name	Value
Engine RPM	5,227 rpm
Boost Pressure	129 kPa
Throttle Inlet Pressure Actual	233 kPa
Throttle Inlet Pressure Desired	229 kPa
Injector Pulse Width	0.0 ms
DI Start Of Injection Angle (Intake)	0.0 °
DI End Of Injection Angle (Compression)	0.0 °
Vehicle Speed	92 km/h
Engine Coolant Temp	93 °C
Intake Air Temp	16 °C
Manifold Absolute Pressure	224 kPa
Timing Advance	2.3 °
Knock Retard	-1.6 °
Accelerator Pedal Position	100.0 %
Throttle Position	57.3 %
Relative Throttle Position (SAE)	45.9 %
Commanded Throttle Actuator (SAE)	56.9 %
Equivalence Ratio Commanded (SAE)	0.843 λ
WB EQ Ratio Bank 1	0.74 λ
Fuel System #1 Status (SAE)	CL - Normal
Short Term Fuel Trim Bank 1	-9.4 %
Long Term Fuel Trim Bank 1	7.0 %
Fuel Rail Pressure Desired	20.684 MPa
Fuel Rail Pressure (SAE)	20.710 MPa
Fuel Level Input (SAE)	96.9 %
Control Module Voltage	13.43 V
Absolute Load (SAE)	200.4 %
Barometric Pressure	94 kPa

RPM (rpm) 5,237
Speed (mph) 57
TIP Actual (kPa) 232.1
TIP Desired (kPa) 229.2
MAP (kPa) 223.9
Absol. Load (%) 199.2
KR (°) -1.6
TP (%) 57.3
Spark (°) 2.5
APP (%) 100.0
Injector (°) 0.0
EQ Err (%) -12.5
EQ Cmd (λ) 0.843
EQ #1 (λ) 0.738
LTFT B1 (%) 7.0
FRP A Cmd (MPa) 20.68
STFT B1 (%) -9.6
Fuel Rail (MPa) 20.74

Created: 4/18/2020 12:00:29 PM Duration: 28m 22s Zoom: 1m Time: 12:18:36.518, 00:18:06.783

Figure 10: Multiple Data Parameters Data Log

Figure 11: Turbo-Boost Pressure test equipment

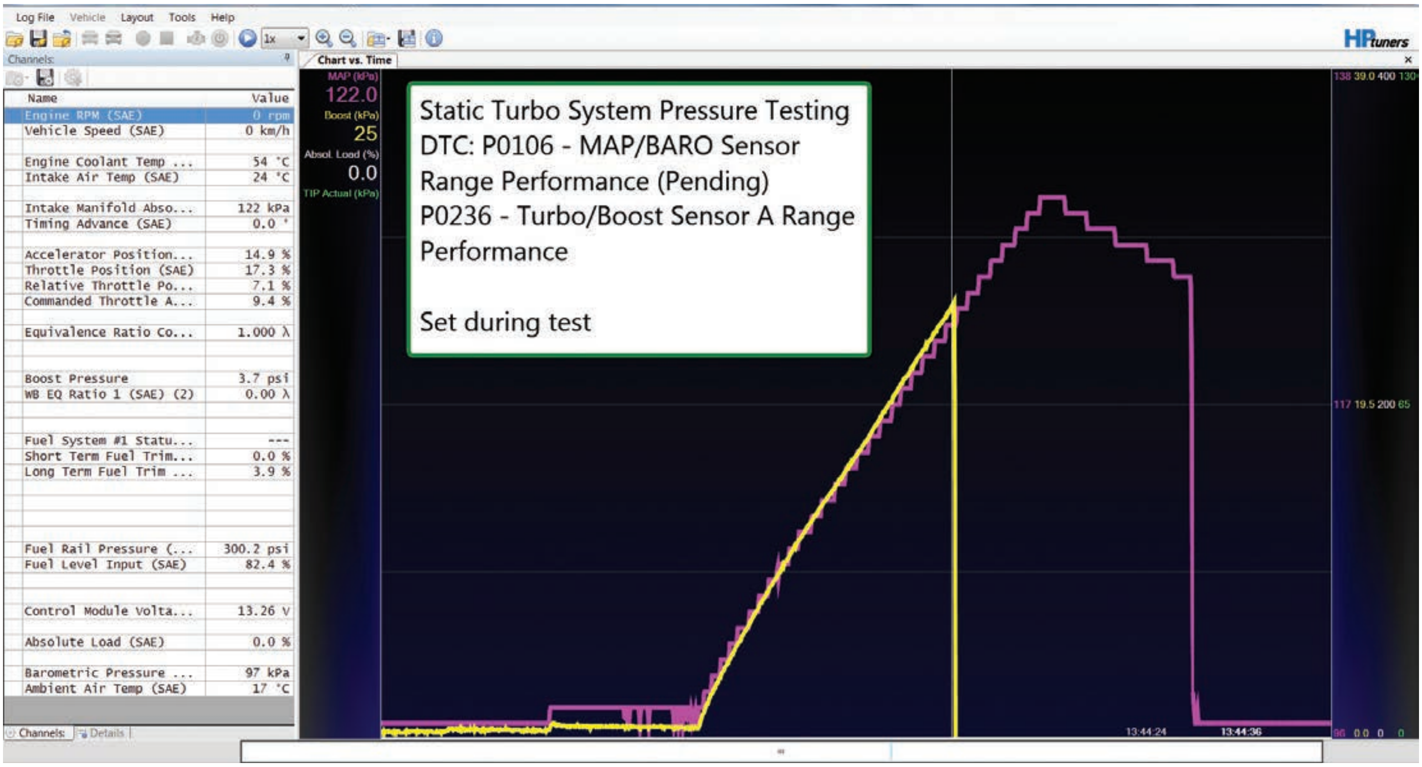
with the 2.3L Turbo DI engine on a long road test. Looking at the time offered on the screen one can make several observations. Let's walk through a few notable items:

1. Load: Cursor shows current measurements for that particular frame. You can see that this is a WOT event where APP = 100 percent, but the TP is being modulated. If you look at absolute load in row #2, you will see 199 percent being reported. What this means is that the engine is able to flow nearly twice the mass of air you can fit into the 2.3L of displacement this engine provides.
2. Equivalence Ratio: This is essentially lambda and if you look at the commanded vs actual in row #3, you'll see that the ECM is over delivering fuel by 12.5 percent, as indicated by the EQ Err PID. Now don't try looking for this PID on your scan tool because this particular PID is a custom math PID that this particular software application offers to the end user.
3. Boost Pressure: Looking back at row #2, you'll see TIP actual, TIP desired and MAP. These are doing a fairly good job of following each other. If you see slow pressure bleed off away from commanded, that could indicate a wastegate valve leak allowing the compressor to slow. If you see a rapid drop in pressure, that is more indicative of a leak that occurs at a specific pressure between the turbo and the intake port. Look at the point where the throttle is released to see the system's ability to dump the pressure.
4. DI Rail Pressure: Looking at row #5 you'll Fuel Rail commanded vs. Actual. At the cursor we have 20.68 MPa commanded with 20.74 MPa (3,003 psi) actual.
5. Fuel Trim: Continuing in row #5 we have LTFT and STFT. At the cursor we have +7 percent LTFT and -9.6 STFT which would leave us with

Name	Value
Engine RPM (SAE)	0 rpm
Vehicle Speed (SAE)	0 km/h
Engine Coolant Temp ...	51 °C
Intake Air Temp (SAE)	24 °C
Intake Manifold Abso...	112 kPa
Timing Advance (SAE)	0.0 °
Accelerator Position...	14.9 %
Throttle Position (SAE)	17.3 %
Relative Throttle Po...	7.1 %
Commanded Throttle A...	9.4 %
Equivalence Ratio Co...	1.050 λ
Boost Pressure	2.2 psi
WB EQ Ratio 1 (SAE) (2)	0.00 λ
Fuel System #1 Statu...	---
Short Term Fuel Trim...	0.0 %
Long Term Fuel Trim ...	3.9 %
Fuel Rail Pressure (...	76.9 psi
Fuel Level Input (SAE)	82.4 %
Control Module Volta...	13.26 V
Absolute Load (SAE)	0.0 %
Barometric Pressure ...	97 kPa
Ambient Air Temp (SAE)	17 °C

Static Turbo System Pressure Testing
2020 Ford Ranger 2.3L

Figure 12: Scan Data Record During Static Pressure testing



Name	Value
Engine RPM (SAE)	0 rpm
Vehicle Speed (SAE)	0 km/h
Engine Coolant Temp ...	54 °C
Intake Air Temp (SAE)	24 °C
Intake Manifold Abso...	122 kPa
Timing Advance (SAE)	0.0 °
Accelerator Position...	14.9 %
Throttle Position (SAE)	17.3 %
Relative Throttle Po...	7.1 %
Commanded Throttle A...	9.4 %
Equivalence Ratio Co...	1.000 λ
Boost Pressure	3.7 psi
WB EQ Ratio 1 (SAE) (2)	0.00 λ
Fuel System #1 Statu...	---
Short Term Fuel Trim...	0.0 %
Long Term Fuel Trim ...	3.9 %
Fuel Rail Pressure (...	300.2 psi
Fuel Level Input (SAE)	82.4 %
Control Module Volta...	13.26 V
Absolute Load (SAE)	0.0 %
Barometric Pressure ...	97 kPa
Ambient Air Temp (SAE)	17 °C

Static Turbo System Pressure Testing
DTC: P0106 - MAP/BARO Sensor Range Performance (Pending)
P0236 - Turbo/Boost Sensor A Range Performance

Set during test

Figure 13: DTCs Set During Pressure testing

approximately -2 percent total fuel trim, which is really good.

6. Spark Advance: In row #3 you'll see both spark advance and knock retard. Not a lot of spark advance is needed to light the mixture and obtain peak cylinder pressure at approximately 12-15 degrees ATDC. Note how the knock retard system is responding properly.

Plumbing

With the additional intercoolers and plumbing comes the difficult task of leak testing. Since these systems run at high pressures, it may prove difficult to properly leak-test these systems without special tools. There are smoke machines available with high-pressure testing capability on the market designed for the one shown in Figure 11.

If you're going to pressure test the system and want to compare the MAP and boost sensors, then connect the scantool and monitor those PIDS KOEO as shown in Figure 12.

Please use caution when pressure testing, and wear proper PPE. Additionally, you will likely set DTCs when performing this test as per the PCM's cross-checking these values against each other and BARO. Also observe that the boost pressure data drops to zero when the fault occurs as shown in Figure 13.

(Note: Boost PID displayed starts at zero unlike the MAP sensor that starts at barometric pressure.)

Heat

Boosted applications generate a lot of heat and require additional considerations. Some manufacturers may perform additional thermal management routines after the vehicle is shut down by running electric water pumps to help cool the turbo/supercharger. If the battery system is insufficient, the system may come up short in this task.

Filters

These systems move a lot of air and, if the air filter gets restricted, it can induce a lot of complications such as increased oil consumption, damage to the PCV system and more. A best practice to follow with these power adder systems is to be very diligent when it comes to maintenance services.

Conclusion

When it comes to boosted applications, there's a lot more to look for when solving driveability complaints. Leveraging knowledge, diagnostic tools, and your investigative skills will, without a doubt, lead you down a path to success. Never stop learning. >

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