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TRAINING CENTER

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## Your Instructor For This Webinar

- National Trainer, ASE World Class, Master Auto, Truck, School Bus, L1, L3, CNG
- ATTP Master Instructor, New York State, CT and New Jersey
- STS (Service Technician Society) 2003 President
- TST (Technicians Service Training) Founder and President
- Author / Co Author/ Technical adviser on 25 plus books including
- OBD II and Mode 6, and Understanding and Diagnosing Hybrid Vehicles
- Published articles for multiple newsletters, and magazines
- Picked as one of the Top Instructors in the country by EPA & SAE
- Numerous Radio, TV, Internet, and SAE Video appearances
- PTEN, MotorAge and TST Webcast Instructor - Dorman Training Director
- Motor Magazine Top 20 award winner
- Provider of OBD II Training for 14 states, Ontario Canada and the US EPA
- Guest speaker at SAE Congress, IM Solutions and Clean Air Conference



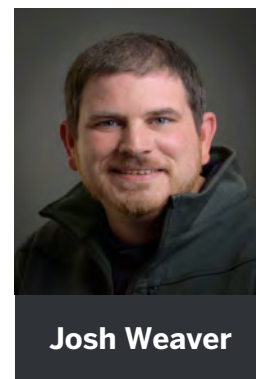
[gtruglia@dormanproducts.com](mailto:gtruglia@dormanproducts.com)



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## Your instructor for this webinar

- Associate Degree in Applied Science for Automotive Technology
- College was affiliated with General Motors and Chrysler, and I interned for Ford allowing me to learn all 3 domestic Brands
- Worked for a Kia dealership for 10 years and achieved Kia Master Tech Status
- Lead tech at the dealership allowing me to see the most difficult customer concerns
- Pennsylvania State inspection Emissions tech with waiver license
- Holds A.S.E. L1 Advance Engine Performance
- Holds A.S.E. L3 Light Duty Hybrid Specialist
- E.P.A. 609
- Manager of a 6 bay repair shop which also had a 6 bay body shop, allowing me to see a wide variety of electrical, drivability issues and module programming



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## What Will Be Covered

Instructions for this Lunch & Learn webinar

- This webinar will be approx. 1 hour long
- All slides that are presented are in your handout and are numbered
- Have a pen or pencil and paper for notes
- Questions can be asked at anytime

- 01 AF Voltage Information
- 02 Scan Data / Graphing
- 03 AFR Voltage Levels
- 04 Mode 6
- 05 OE Scan Tool Info Hyundai - Air Fuel
- 06 Case Studies

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## Air Fuel Sensor Information

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## AF Voltage Levels Info

### AF Sensor :

For example, vehicles that use AF sensors always have this sensor before the catalytic converter and a regular HO<sub>2</sub>S after the catalytic converter. **HO<sub>2</sub>S switches voltage from rich to lean, while the A/F stays at close to a steady voltage state.**

That steady voltage differs by the vehicle manufacturer. Plus, it can only be measured accurately in most cases with a scan tool in Enhanced OBD II mode or by factory software, as well as with a meter. Because many foreign vehicles use the AF sensor, be aware that many **aftermarket scan tools may not read or display the readings properly in Generic OBD II.**

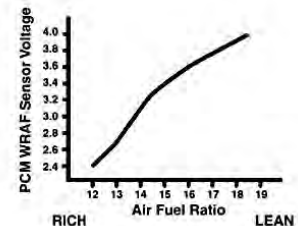
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## Air Fuel / Wide Range

- **The normal range for a Toyota AF sensor is 2.8 - 3.8 volts at idle, but don't be surprised to see the actual readings in an idling engine hover very close to the 3.3 volt center point that indicates a stoichiometric air/fuel mixture of 14.7:1.**
- **Remember, this sensor doesn't bracket the mixture with high and low voltage toggles, it measures the mixture exactly. Voltage does not dither with the AF sensor.**



Wide Range  
Air/ Fuel Sensor



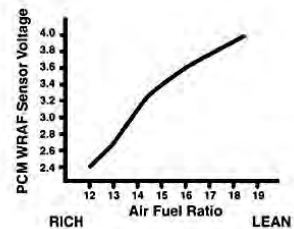
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## AF Voltage Levels Info

- At 2.8 volts (lower than 3.3 volts) the AF sensor PID indicates a rich mixture.
- This is opposite our normal inclination to view high voltages as a rich indicator, and low ones as a lean indicator, so be careful.



Wide Range  
Air/ Fuel Sensor



## AF Voltage Levels Info

- Generic / Global scan tools may not display the true voltage.
- OBD II standards requiring O2 sensor PID voltage to be displayed in a range between zero and 1 volt.
- Instead, what you'll see is a *percentage* of true voltage. To display the *actual* PCM PID voltage, you'll need a scan tool with enhanced/factory software.



**It's pretty tough to accurately display voltage levels that start at 3.3 volts using a 0 - 1 volt scale.** Some scan tools may display a Toyota 3.3 voltage at approximately 0.685 volts.

# Scan Tool AF Sensor Data

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## Understanding AFR Voltage Levels On Scan Tools

**The Toyota O2 Sensor voltages did not move because they are AF sensors. The tool was not configured properly many years ago along with other companies such as Snap-On.**

| Supported PIDs                            | Abbrev      | Data      | Units |
|---|-------------|-----------|-------|
| ✓ Calculated Load                         | LOAD_PCT    | 13.7255   | %     |
| ✓ Engine Coolant Temperature              | ECT         | 194.0000  | Deg F |
| ✓ Short Term Fuel Trim Bank 1             | SHRTFT1     | 0.0000    | %     |
| ✓ Long Term Fuel Trim Bank 1              | LONGFT1     | 4.6875    | %     |
| ✓ Short Term Fuel Trim Bank 2             | SHRTFT2     | 0.0000    | %     |
| ✓ Long Term Fuel Trim Bank 2              | LONGFT2     | 5.4687    | %     |
| ✓ Engine RPM                              | RPM         | 2398.0000 | RPM   |
| ✓ Vehicle Speed Sensor                    | VSS         | 0.0000    | mph   |
| ✓ Ignition Timing Advance for #1 Cylinder | SPARKADV    | 39.5000   | deg   |
| ✓ Intake Air Temperature                  | IAT         | 100.4000  | Deg F |
| ✓ Air Flow Rate from Mass Air Flow Sensor | MAF_g/s     | 10.0000   | g/s   |
| ✓ Air Flow Rate from Mass Air Flow Sensor | MAF_lb/m    | 1.3200    | lb/m  |
| ✓ Absolute Throttle Position              | TP          | 15.2941   | %     |
| ✓ O2 Bank 1 - Sensor 1                    | O2B1S1      | 0.6450    | V     |
| ✓ O2 Bank 1 - Sensor 2                    | FTB1S1      | 0.0000    | %     |
| ✓ O2 Bank 1 - Sensor 2                    | O2B1S2      | 0.1850    | V     |
| ✓ O2 Bank 1 - Sensor 2                    | FTB1S2      | 99.2187   | %     |
| ✓ O2 Bank 2 - Sensor 1                    | O2B2S1      | 0.6550    | V     |
| ✓ O2 Bank 2 - Sensor 1                    | FTB2S1      | 0.0000    | %     |
| ✓ Total Trim Bank1 (Calculated)           | TotalTrimB1 | 4.6875    | %     |
| ✓ Total Trim Bank2 (Calculated)           | TotalTrimB2 | 5.4687    | %     |
| ✓ Cross Rate O2B1S1 (Calculated)          | O2Cross11   | 0.0000    | Hz    |
| ✓ Cross Rate O2B1S2 (Calculated)          | O2Cross12   | 0.0000    | Hz    |
| ✓ Cross Rate O2B2S1 (Calculated)          | O2Cross21   | 0.0000    | Hz    |
| ✓ Engine Running Time (Calculated)        | RunTime     | 261.9010  | s     |
| ✓ Fuel Control Monitor Bank1 (Calculated) | FctrMonB1   | 100.0000  | %     |
| ✓ Fuel Control Monitor Bank2 (Calculated) | FctrMonB2   | 100.0000  | %     |
| ✓ Fuel Trim Bank1 to Bank2 (Calculated)   | FTB1toB2    | -0.7812   | %     |
| ✓ Catalyst Efficiency Bank1 (Calculated)  | CalEBB1     | 0.0000    | %     |
| ✓ Battery Voltage at DLC (Calculated)     | BatteryV    | 14.0000   | V     |
| ✓ Closed Loop 1 (Calculated)              | ClosedLp1   | 1.0000    |       |
| ✓ Closed Loop 2 (Calculated)              | ClosedLp2   | 1.0000    |       |

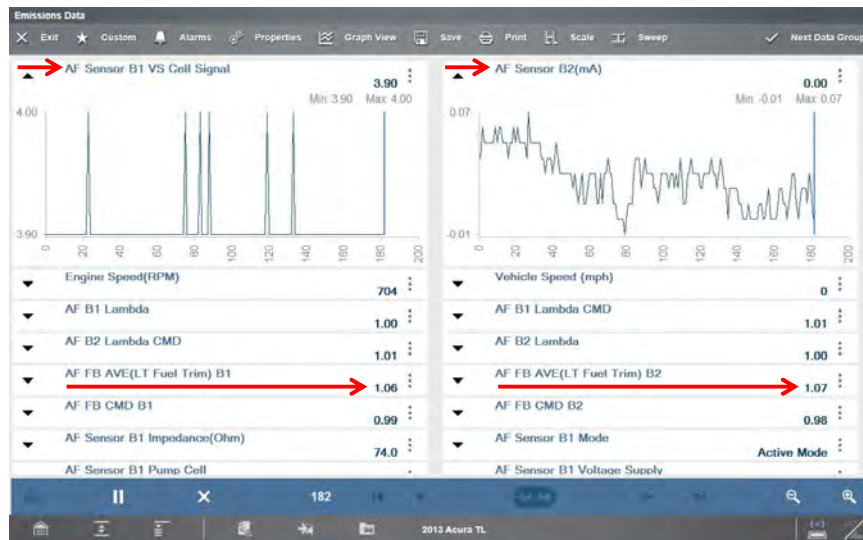
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## AF Scan Data



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## Scan Tool Graphing Data



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# Air Fuel Sensor Designs

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## Air Fuel Sensor Designs

### **4 And 5 Wire Air Fuel Sensors**

- **Ford: 1997 intro (5 wire sensors)**
- **Subaru: 1999 intro (4 wire sensors)**
- **Toyota: 1997 intro (4 wire sensors)**
- **Honda: 1998 intro (4 wire sensors)**
- **Nissan: 2007 intro (5 wire sensors)**

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## 4 And 5 Wire Air Fuel Sensors

- All 4 wire sensors will be Denso
- All 5 wire sensors will be Bosch and NTK
- 5 wire sensors may have 6 to 7 wires going out to the vehicle.



## AF Voltage Levels Info

### 4 And 5 Wire Air Fuel Sensors

- All 4 wire sensors will be Denso
- All 5 wire sensors will be Bosch and NTK
- 5 wire sensors may have 6 to 7 wires going out to the vehicle.

# Understanding AF Voltage Levels

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## Understanding AF Voltage Levels

**The lower the AF sensor voltage, the richer the mixture and the higher the voltage, the leaner the engine is running. This is opposite from our normal inclination to view high voltages as a rich indicator, and low ones as a lean indicator, so be careful.**

For example, good AF sensor reading at idle are:

**2.8 V Honda**

**1.9 V Hyundai**

**1.4 V Nissan**

**2.4 V Subaru**

**3.3 V Toyota**

**1.00 Lambda (all European manufacturers)**



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## 2015 Ford 2.0L Scan Tool Air Fuel

Code Description  
No DTC Codes Present  
Pending Codes:  
P2196 O2 Sensor Signal Stuck Rich Bank 1 Sensor 1

| Supported PIDs                          | Abbrev    | Data       | Units |
|---|-----------|------------|-------|
| Engine RPM                              | RPM       | 724.7500   | RPM   |
| Vehicle Speed Sensor                    | VSS       | 0.0000     | mph   |
| Ignition Timing Advance for #1 Cylinder | SPARKADV  | 8.5000     | deg   |
| Intake Air Temperature                  | IAT       | 80.6000    | Deg F |
| Absolute Throttle Position              | TP        | 11.3725    | %     |
| O2 Bank 1 - Sensor 2                    | O2B1S2    | 0.9160     | V     |
| O2 Bank 1 - Sensor 2                    | FTB1S2    | 99.2187    | %     |
| Time Since Engine Start                 | RUNTIME   | 1382.0000  | s     |
| Fuel Rail Pressure                      | FRP       | 513.8215   | HG    |
| Commanded Evaporative Purge             | EVAP_PCT  | 0.0000     | %     |
| Fuel Level Input                        | FLI       | 58.0392    | %     |
| Number of Warm-ups Since DTCs Cleared   | WARM_UPS  | 255.0000   |       |
| Distance Since DTCs Cleared             | CLR_DIST  | 10106.7754 | miles |
| Evap System Vapor Pressure              | EVAP_VP   | 33.2500    | Pa    |
| Barometric Pressure                     | BARO      | 29.2347    | HG    |
| Bank 1 - Sensor 1 (Wide Range O2S) (mA) | LAMD411mA | 0.6622     | Ratio |
| Bank 1 - Sensor 1 (Wide Range O2S) (mA) | O2S11mA   | -2.0586    | mA    |
| Catalyst Temperature Bank 1, Sensor 1   | CATEMP11  | 901.7600   | Deg F |
| Control Module Voltage                  | VPWR      | 14.2490    | V     |
| Absolute Load Value                     | LOAD_ABS  | 16.4914    | %     |
| Commanded Enrichment Ratio              | REQ_RATIO | 0.9894     | Ratio |



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## Wide Range (WR) / Air Fuel (AF)

Supported PIDs

| Supported PIDs                          | Abbrev    | Data     | Units |
|---|-----------|----------|-------|
| ✓ Long Term Fuel Trim Bank 2            | LONGFT2   | 14.8437  | %     |
| ✓ Engine RPM                            | RPM       | 675.0000 | RPM   |
| Vehicle Speed Sensor                    | VSS       |          | km/h  |
| Ignition Timing Advance for #1 Cylinder | SPARKADV  |          | deg   |
| Intake Air Temperature                  | IAT       |          | Deg C |
| Air Flow Rate from Mass Air Flow Sensor | MAF_gls   |          | g/s   |
| Air Flow Rate from Mass Air Flow Sensor | MAF_lb/m  |          | lb/m  |
| ✓ Absolute Throttle Position            | TP        | 15.6863  | %     |
| O2 Bank 1 - Sensor 2                    | O2B1S2    |          | V     |
| O2 Bank 1 - Sensor 2                    | FTB1S2    |          | %     |
| O2 Bank 2 - Sensor 2                    | O2B2S2    |          | V     |
| O2 Bank 2 - Sensor 2                    | FTB2S2    |          | %     |
| Time Since Engine Start                 | RUNTIME   |          | s     |
| Distance Traveled When MIL is Activated | ML_DIST   |          | km    |
| Bank 1 - Sensor 1 (Wide Range O2S) (V)  | LAMD411   | 1.0615   | Ratio |
| Bank 1 - Sensor 1 (Wide Range O2S) (V)  | O2S11     | 3.3958   | V     |
| Bank 2 - Sensor 1 (Wide Range O2S) (V)  | LAMD421   | 1.0030   | Ratio |
| Bank 2 - Sensor 1 (Wide Range O2S) (V)  | O2S21     | 3.2846   | V     |
| Commanded Evaporative Purge             | EVAP_PCT  |          | %     |
| Number of Warm-ups Since DTCs Cleared   | WARM_UPS  |          |       |
| Distance Since DTCs Cleared             | CLR_DIST  |          | km    |
| Barometric Pressure                     | BARO      |          | hPa   |
| Bank 1 - Sensor 1 (Wide Range O2S) (mA) | LAMD411mA |          | Ratio |
| Bank 1 - Sensor 1 (Wide Range O2S) (mA) | O2S11mA   |          | mA    |
| Bank 2 - Sensor 1 (Wide Range O2S) (mA) | LAMD421mA |          | Ratio |
| Bank 2 - Sensor 1 (Wide Range O2S) (mA) | O2S21mA   |          | mA    |
| Catalyst Temperature Bank 1, Sensor 1   | CATEMP11  |          | Deg C |
| Catalyst Temperature Bank 2, Sensor 1   | CATEMP21  |          | Deg C |
| Catalyst Temperature Bank 1, Sensor 2   | CATEMP12  |          | Deg C |
| Catalyst Temperature Bank 2, Sensor 2   | CATEMP22  |          | Deg C |
| Control Module Voltage                  | VPWR      |          | V     |
| Absolute Load Value                     | LOAD_ABS  |          | %     |



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# Air Fuel Sensor - Mode 6

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## Toyota AF Mode 6

The screenshot displays the 'Toyota AF Mode 6' diagnostic screen. The interface includes a sidebar on the left with fuel trim controls (RICH, LEAN, CENTER, Stoichiometric, FUEL TRIM, TOTAL FUEL TRIM, Bank to Bank Fuel Trim, Time to Engine Temperature, Charging Voltage, MIL ON, Monitoring Not Complete). The main area shows a table of data points:

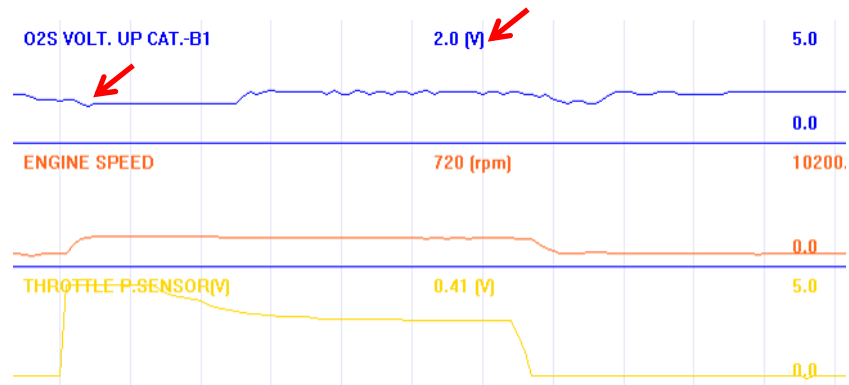
| DTD Monitor ID (OBD/MD)          | Test ID (TID)                 | Test Value | Min Limit | Max Limit | Units  |
|----------------------------------|-------------------------------|------------|-----------|-----------|--------|
| \$01: B151 AF Sensor Monitor     | \$8E: B151 AF Response Rate   | 0.809      | 0.000     | 5.996     |        |
| \$01: AF Sensor Heater Monitor   | \$91: B151 AF Sensor Current  | 1.405      | 1.405     | 3.590     | mA     |
| \$02: B152 Oxygen Sensor Monitor | \$05: Description Unavailable | 0.040      | 0.000     | 2.990     | s/c    |
| \$02: B152 Oxygen Sensor Monitor | \$06: Description Unavailable | 0.153      | 0.000     | 2.990     | s/c    |
| \$02: B152 Oxygen Sensor Monitor | \$07: Min. Sensor Voltage     | 0.019      | 0.000     | 0.448     | V      |
| \$02: B152 Oxygen Sensor Monitor | \$08: Max. Sensor Voltage     | 0.878      | 0.605     | 1.000     | V      |
| \$02: B152 Oxygen Sensor Monitor | \$84: Description Unavailable | 0.000      | 0.000     | 0.000     | %      |
| \$02: B152 Oxygen Sensor Monitor | \$85: Description Unavailable | 19.998     | 19.998    | 100.006   | %      |
| \$02: B152 Oxygen Sensor Monitor | \$86: Description Unavailable | 0.000      | 0.000     | 0.000     | s/c    |
| \$02: B152 Oxygen Sensor Monitor | \$87: Description Unavailable | 0.000      | 0.000     | 0.000     | %      |
| \$02: B152 Oxygen Sensor Monitor | \$88: Description Unavailable | 0.000      | 0.000     | 0.000     | %      |
| \$02: B152 Oxygen Sensor Monitor | \$8A: Description Unavailable | 5.000      | 2.000     | 65535.000 | Counts |
| \$02: B152 Oxygen Sensor Monitor | \$8B: Description Unavailable | 0.015      | 0.000     | 0.998     | s/c    |
| \$02: B152 Oxygen Sensor Monitor | \$8D: Description Unavailable | 1.392      | 0.000     | 5.995     | s/c    |
| \$08: B251 AF Sensor Monitor     | \$8E: B251 AF Response Rate   | 1.802      | 0.000     | 5.996     |        |
| \$08: AF Sensor Heater Monitor   | \$91: B251 AF Sensor Current  | 2.351      | 1.405     | 3.590     | mA     |
| \$08: B252 Oxygen Sensor Monitor | \$05: Description Unavailable | 0.122      | 0.000     | 2.990     | s/c    |
| \$08: B252 Oxygen Sensor Monitor | \$06: Description Unavailable | 0.122      | 0.000     | 2.990     | s/c    |
| \$08: B252 Oxygen Sensor Monitor | \$07: Min. Sensor Voltage     | 0.155      | 0.000     | 0.448     | V      |
| \$08: B252 Oxygen Sensor Monitor | \$08: Max. Sensor Voltage     | 0.800      | 0.605     | 1.000     | V      |
| \$08: B252 Oxygen Sensor Monitor | \$84: Description Unavailable | 0.000      | 0.000     | 0.000     | %      |
| \$08: B252 Oxygen Sensor Monitor | \$85: Description Unavailable | 0.000      | 0.000     | 0.000     | %      |
| \$08: B252 Oxygen Sensor Monitor | \$86: Description Unavailable | 0.000      | 0.000     | 0.000     | s/c    |
| \$08: B252 Oxygen Sensor Monitor | \$87: Description Unavailable | 30.004     | 30.004    | 100.005   | %      |
| \$08: B252 Oxygen Sensor Monitor | \$88: Description Unavailable | 0.000      | 0.000     | 0.000     | %      |
| \$08: B252 Oxygen Sensor Monitor | \$8A: Description Unavailable | 2.000      | 2.000     | 65535.000 | Counts |

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# OE Scan Tool Information Hyundai - Air Fuel Sensor

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## Understanding AF Voltage Levels On Scan Tools

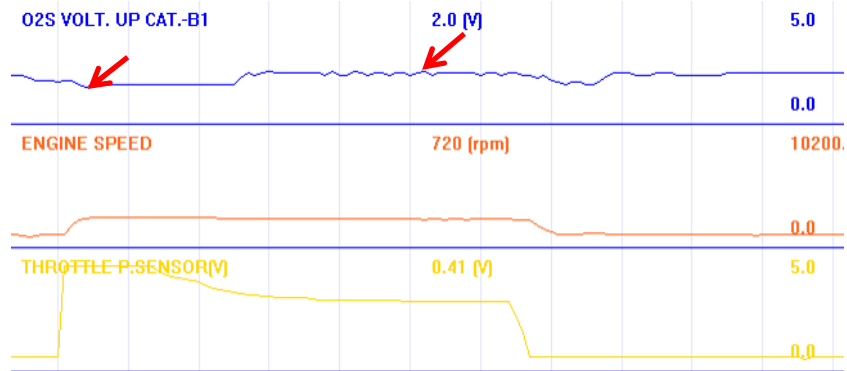


**The Hyundai - Kia and factory tool was not configured properly either. Take a look at the O2 Sensor voltage and you will notice it's stated as an O2S with a voltage average of 2.0 volts. The normal reading is 1.9 volts for their AF sensor.**

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## Understanding AF Voltage Levels On Scan Tools

To the contrary, when the condition is lean their voltage spikes. Look at the following graph as an example.

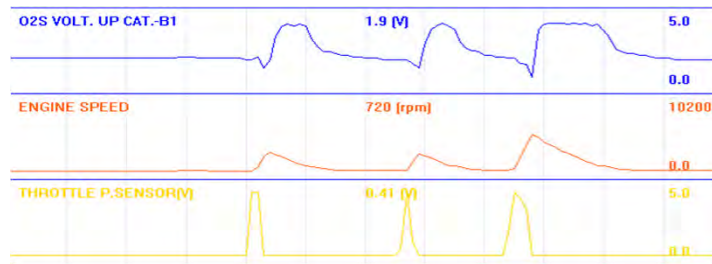


Don't get confused by scan tool PIDS. *The graphs above can be confusing if you are not aware that the Hyundai - Kia factory scan tool displays A/F sensor as O2S.*

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## Air/Fuel Sensor Rich And Lean Conditions

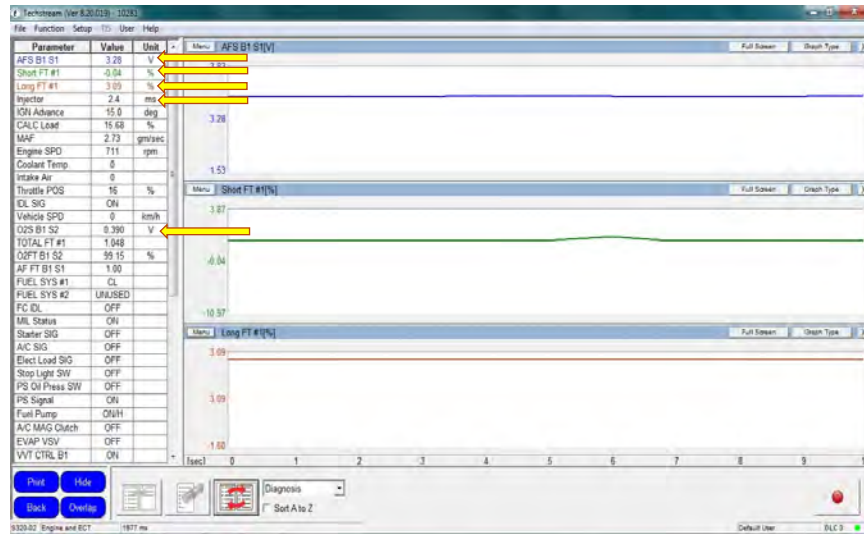
As a throttle position and engine speed go up and the mixture gets richer, the voltage declines. Voltage goes up when engine speed and throttle position decline, as the mixture is leaned out to bring the car back to proper air - fuel mixture.



Don't get confused by scan tool PIDS. *The graphs above can be confusing if you are not aware that the Hyundai - Kia factory scan tool displays A/F sensor as O2S.*

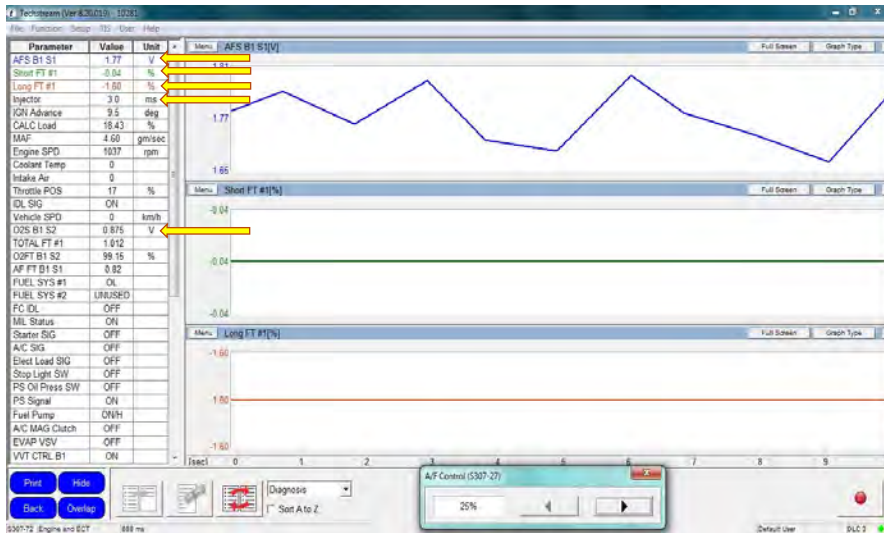
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## 2005 Scion tc 2.4L Normal About 3.3 V AF Readings



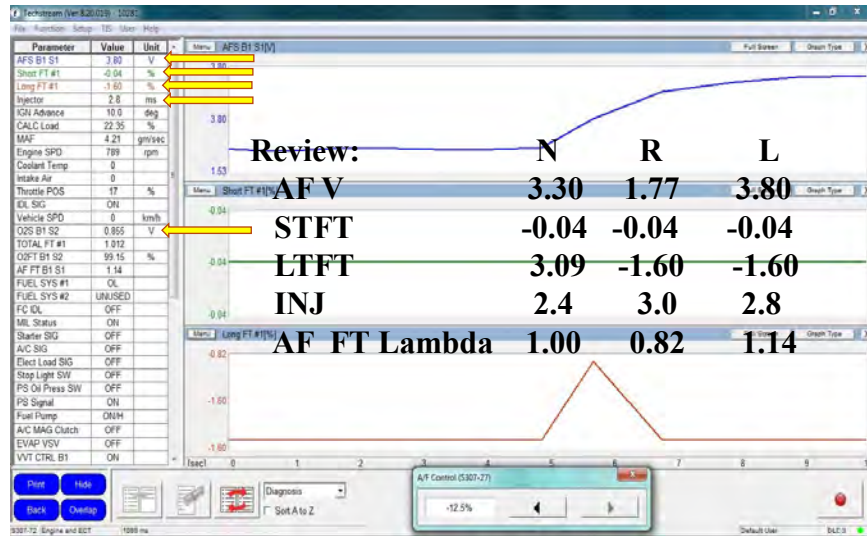
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## 2005 Scion tc 2.4L 25% RICH Added AF Control



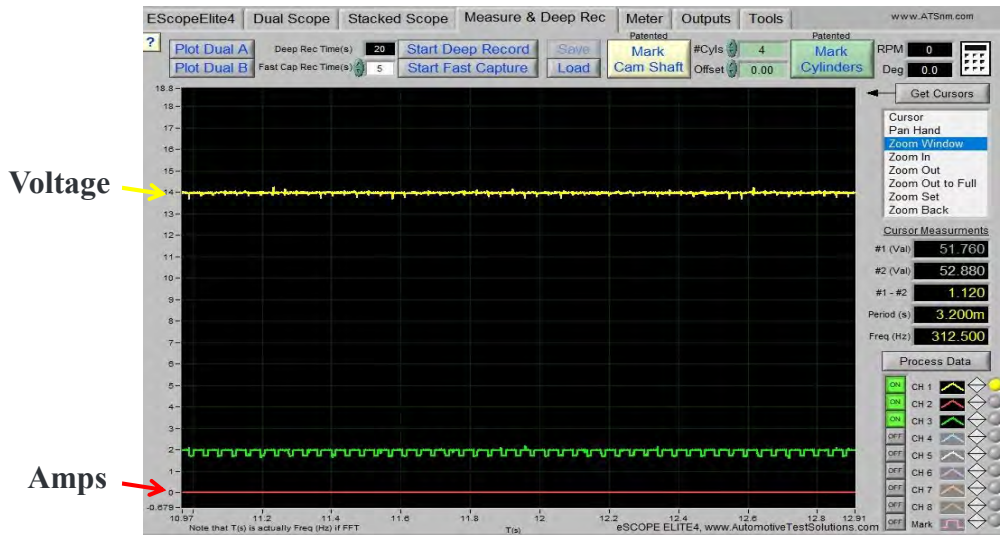
30

## 2005 Scion tc 2.4L -12.5% LEAN Taken AF Control



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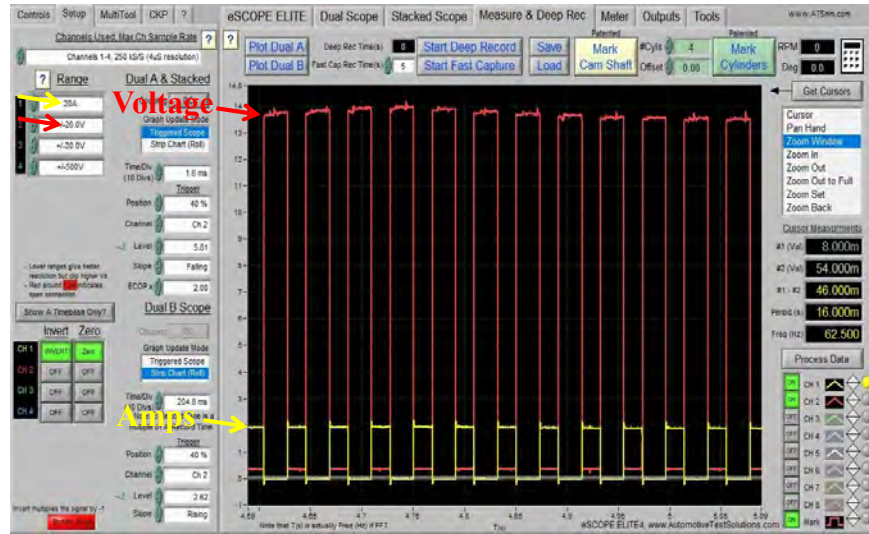
## 2008 Toyota Camry Air Fuel Heater Current And Voltage



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## 2008 Toyota Camry Air Fuel Heater Current And Voltage



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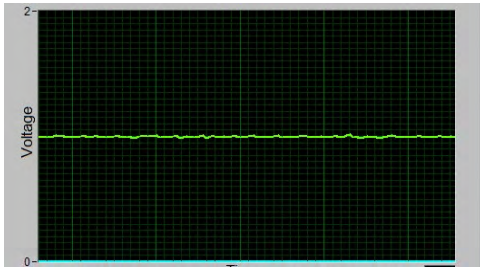
## AF Front & O2 Rear Sensor



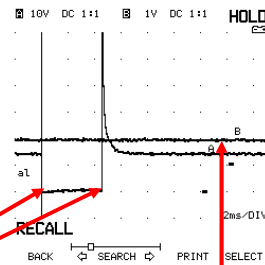
34



## AF Sensor Fuel Control

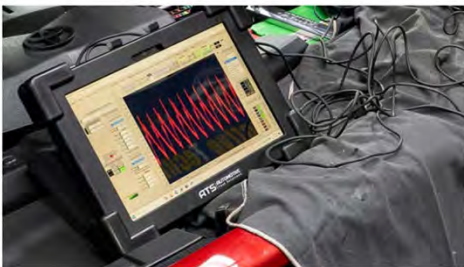


Air Fuel



Fuel Injector (more pulse width = **RICH**, less = **LEAN**)

AF Sensor (**HIGH voltage/ up LEAN, LOW = RICH condition**)



### Scan Tool Tips and Tricks - Live Webinar

Thursday, August 8, 2024

6:00 p.m.—8:00 p.m. EST

This webinar covers tips and tricks to help scan tool users identify and diagnose causes of common problems, including fuel delivery issues, misfires and fuel trims.

Instructor: Josh Weaver





**Thursday August 22<sup>nd</sup>, 2024**

**Heavy Duty Lunch & Learn 12:00pm to 1:00pm ET**

**"The Journey Continues" - HD OBD II - Part 2**

In this webinar we will continue on where we left off in Part 1. What will be covered is Codes/DTCs, looking at testing and commending sensors that have to me OBD II requirements.

**Instructor: Swede Oun**



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## ***Understanding and Diagnosing Air Conditioning***

This course goes beyond minimum certification requirements for recovery, evacuating, recharging, and recycling by offering actual hands-on training in diagnosing and repairing A/C electrical, computer / BCMs, Climate control and electronic components. Many of today's trucks & vehicles come equipped with electronically controlled A/C systems.

**Includes books, safety glasses & MACS Certification in R134a and R1234yf**

Class Limit 18 technicians

**Safety Glasses MUST be worn during the hands on vehicle training**

**2 Days / 16 hours - \$695.00**

**Book, Safety Glasses and Lunch Included**

**Instructors: Swede Oun & "G" Jerry Truglia**

**Dates: August 27th & 28th, 2024**

**Time: 8:00 AM to 4:30 PM**

Location: O&K Truck Repairs Ltd.

350 Grand Island Blvd.

Tonawanda, NY 14150

Technicians MUST Register & Pre Pay

[www.dormantrainingcenter.com](http://www.dormantrainingcenter.com)

Phone: 845 628-1062 or 716.874.5450

[drestucci@dormanproducts.com](mailto:drestucci@dormanproducts.com)



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## **Dorman Second Annual "Mastering the Technology"**

**All Day LIVE Training Event & Trade Show**

**When: Saturday, September 21st 2024**

**Time: 7 am to 6 pm**

**Where: ATC Automotive Training Center 900 Johnsville Boulevard, Warminster, PA 18974**

### **Classes & Instructors:**

- 1. First Steps In Electrical Diagnosis - Pete Meier**
- 2. Maintaining Control - Air Fuel Sensors And Drivability - Ken Zanders**
- 3. A Diag Buffet - Case Studies From The Real World - "G" Jerry Truglia**

**Only 192  
Seats  
Left**

**What's Included: food and full color downloadable books**

**Cost: Special Introductory Price : \$50.00**



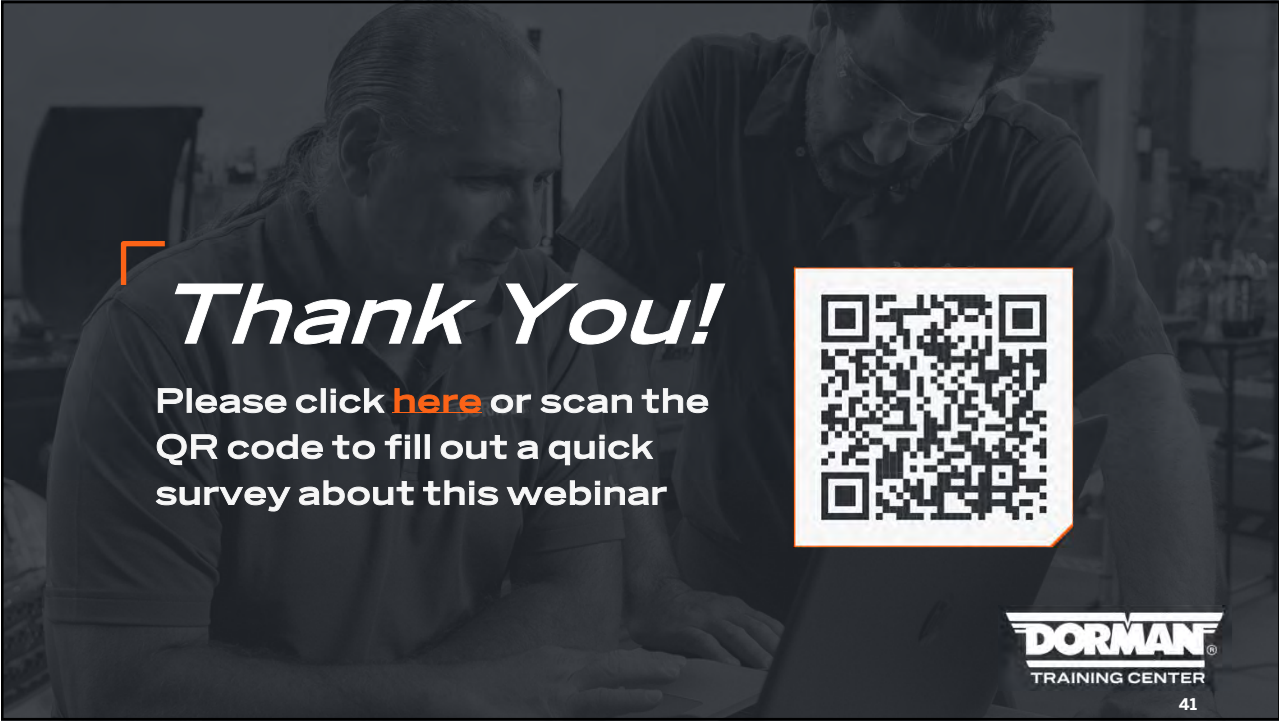
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# *Questions?*




40

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***Thank You!***

Please click [here](#) or scan the QR code to fill out a quick survey about this webinar



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