Introduction

This O_2 sensor clamp is designed for use with the Greddy eManage Ultimate engine control system. While these instructions are specific to the Mazda MX-5 Miata, the clamp will work on any vehicle which uses a factory narrowband O_2 sensor (1, 2, or 4-wire types). The O_2 sensor clamp is designed to prevent the ECU from causing lean mixture conditions at the tip-in to boost in both turbocharged and supercharged applications. It is not intended to correct fuel problems in other operating conditions, or to address ignition timing matters.

Open Loop vs. Closed Loop

The term “closed loop” comes from the fact that the operation of the airflow meter, fuel injectors, and O_2 sensor(s) in a modern engine constitute what engineers refer to as a closed system: measuring the airflow into the engine, calculating and injecting fuel, then observing the resultant exhaust gas to confirm that the fuel and air are reacting correctly.

Under normal operating conditions, the ECU operates in closed-loop mode. Whether idling, cruising, accelerating or decelerating, the ECU is monitoring the O_2 sensor to double-check and fine tune its fuel calculations. If the mixture seems slightly lean (indicated by a low voltage on the O_2 sensor, below about 0.45V) then the ECU adds some fuel to its next injection cycle. If the mixture seems rich (indicated by a high voltage, above 0.45V) the ECU will subtract some fuel the next time around.

There are certain situations when the ECU goes into open-loop mode, meaning that it ignores the O_2 sensor and injects fuel based on load tables (airflow vs. RPM) alone. Removing the O_2 sensor from the equation “opens” the monitoring loop. Open-loop operation occurs when the engine is first started for example, since the O_2 sensor takes time to come up to normal operating temperature. The ECU also runs open-loop when the load is extremely high- this is done intentionally to provide a richer-than-stoichiometric mixture to the engine, providing best torque and a slight safety factor, at the expense of emissions.

The Purpose of an O_2 Sensor Clamp

When dealing with forced induction, we need to add additional fuel to the engine when in boost, with the goal of maintaining an AF/R generally within the range of 11.5:1 to 12.5:1. Different engines will have different targets, depending on efficiency, intercooling, timing, and so on. The catch is that we must sometimes do this without the ECUs knowledge, since if it detects a richer AF/R than it deems necessary while in closed-loop operation, it will reduce fuel to compensate, thereby frustrating our attempts to maintain a deliberately rich mixture.

Under most boosted operating conditions, the ECU will have determined that the load (airflow vs. RPM) is sufficiently high that it should be operating in open-loop anyway, and this conflict will not occur. There are however certain operating conditions where this will not be the case. A small turbo which spools quickly, for example, may be producing considerable boost at very low RPMs. In this situation, the ECU may still be trying to operate in closed-loop despite the fact that the engine is now in boost and we wish to add fuel.

Despite what you may have heard, O_2 clamps do not force the ECU into open-loop mode. Only the ECU itself can make that determination. The function of the O_2 clamp is to prevent the ECU from seeing the true AF/R, by feeding it a simulated signal. Thus, even if the ECU is attempting to operate in closed-loop, it will see only the false O_2 signal that we are sending it, and thus not act to reduce fuel. There is some debate about the proper signal level to use for this purpose, ranging from “very lean” (around 300 millivolts) to “slightly on the lean side of stoichiometric” (about 400mv). Your O_2 clamp has been pre-set to generate a voltage of appx. 370mv, which happens to be where I have mine set.

Installation

Disconnect the vehicle’s negative battery cable before you begin. If your radio has a security code, make note of this first.

The O_2 clamp should be securely mounted inside the vehicle where it is not exposed to moisture. If, for example, you happen to carry a large, drooling dog in your car from time to time, place the clamp where it will not be exposed to salivary emission. Also bear in mind that this is a convertible, and unless you live in Temecula, CA, the interior of the vehicle is likely to get rained on from time to time.

Preferably it should be mounted next to the ECU in order to minimize the length of wire runs.

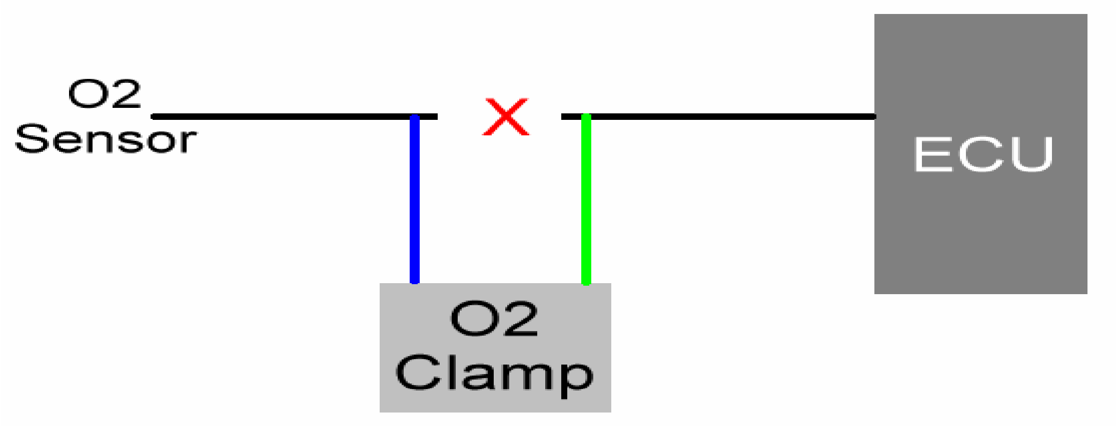
The O_2 clamp has five wires, as follows:
Red: +12V
Black: Ground
White: Trigger
Blue: Input from stock O_2 sensor
Green: Output to ECU

The red wire should be connected to a +12 wire which is hot when the key is on, and the black wire to ground. Optimally, these connections should be made to the same wires that feed the stock ECU.

The white trigger wire is connected to the EMU’s VTEC output lead. This is pin 14 on connector B. If you are using the #15901500 EMU harness, it is a yellow wire.

The blue and green wires will connect to the vehicle’s O_2 sensor wire. For vehicles with two O_2 sensors, it is the forward sensor that we are concerned with. The exact location and color of this wire varies by year, but it will always be covered in a black sleeve until the point where it enters the ECU. Here is a partial list of Year/Color/Pin combinations for various US-spec Miatas. These are based off of unofficial documentation, it is suggested that you verify this against you car’s specific factory manual, which will also show detail as to the location of each pin in the connector:
’90-‘95 Red wire with blue stripe, pin 2N.
’96-’97: Blue wire with red stripe or Red wire with green stripe, pin 3C
’99-’00: Blue wire, pin 2C.
’01-’05: Blue wire, pin 4W.

Regardless of the year or wire color, the basic premise is the same. You must peel back the sleeve and cut this wire a few inches from the ECU. The side of the wire that connects to the ECU should be attached to the green wire of the O_2 clamp. The side of the cut wire that disappears into the vehicle’s harness (and back to the sensor itself) should be connected to the blue wire of the O_2 clamp. Refer to the following diagram when making this connection.

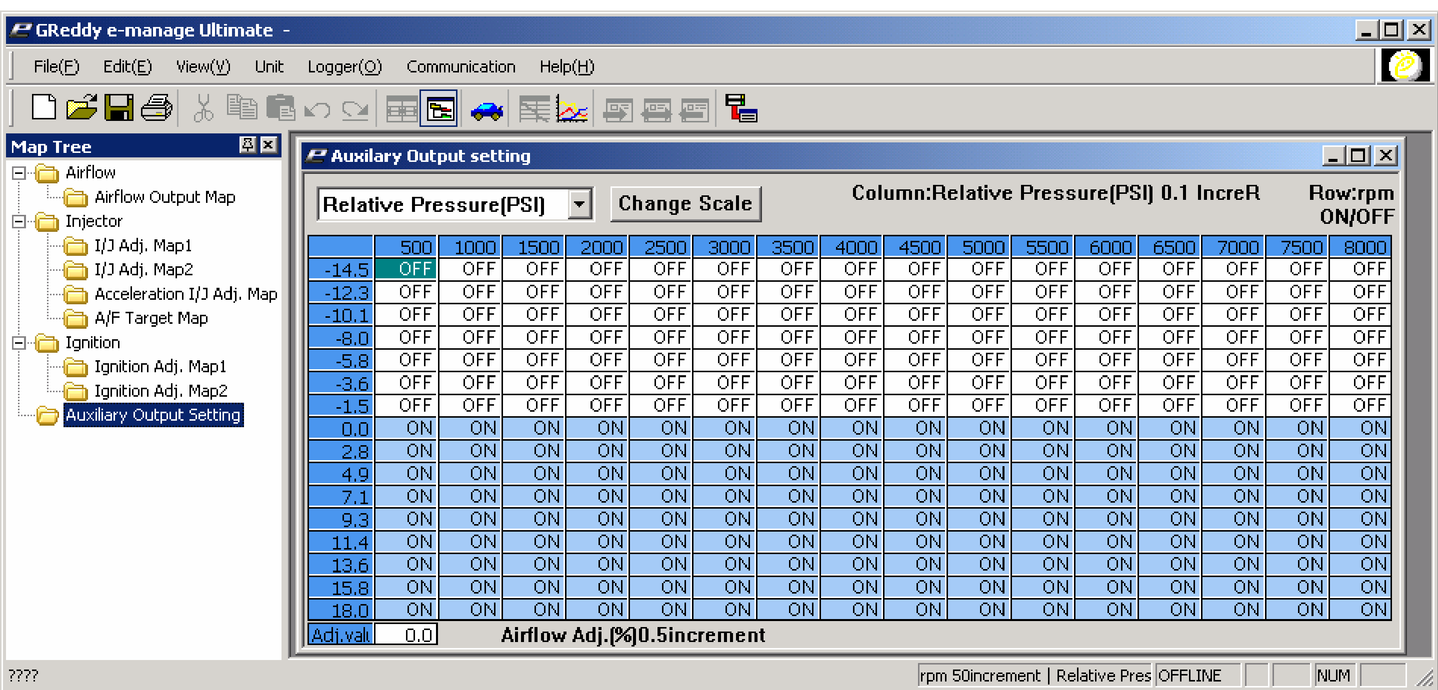


The use of bullet-style crimp connectors is suggested for the blue, green and white wires to allow for easy installation and removal of the O_2 clamp. Connections to +12 and ground can be made with T-taps (also called vampire taps) to attach to the existing wires which supply the ECU / EMU. When finished, re-connect the battery cable.

EMU Configuration

Open your EMU configuration software, load your configuration, and open the Parameters menu. On the "Map Select" tab, ensure that "Auxiliary Output Setting" is checked. Then close the Parameters menu.

You will now have an Aux output map available, which will look somewhat like the following:



	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000
-14.5	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
-12.3	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
-10.1	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
-8.0	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
-5.8	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
-3.6	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
-1.5	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF
0.0	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
2.8	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
4.9	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
7.1	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
9.3	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
11.4	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
13.6	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
15.8	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
18.0	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON

It is suggested that, if necessary, the MAP column along the left be re-scaled so that it matches the A/F Target and I/J Adjust maps. This will ensure that the clamp operates precisely when needed. Setting a cell to "ON" activates the O_2 clamp (sending the simulated signal to the ECU) while setting a cell to "OFF" deactivates the clamp, allowing the actual O_2 sensor signal to pass. The transition from OFF to ON should occur at the same point that you begin to make adjustments in the fuel map, generally at the transition from vacuum into boost. In this example (which is my actual map) all cells at and below 0PSI (relative) are set to ON.

Once you have set your map appropriately, save the file and export it to your EMU.

Adjustment

You may find it necessary to adjust the clamp's simulated voltage away from the pre-set value of 370mv (0.37 volts). To do this, it will be necessary to force the clamp ON while measuring the voltage of the green wire relative to ground with a good voltmeter. The inexpensive digital multimeters sold by Radio Shack and others are sufficient for this purpose, however most analog meters are inadequate as they do not offer precise measurement at very low voltages. To achieve this measurement, set the meter to VDC (or mVDC, if applicable), attach the red probe to the green wire, and the black probe to ground or the black wire.

To force the clamp on, either disconnect the white wire and apply +12 volts to it, or temporarily change all cells in the Aux Output Map to "ON". During this adjustment, the power to the car should be on, however the engine should not be running. It is advised that you disconnect your igniter ('90-'93) or ignition coils ('94+) to prevent damage, as they do not like to sit energized but idle for long periods.

If you choose to disconnect the white wire, be sure to re-attach it prior to driving. Additionally, it is suggested for maximum precision that the green wire be *left connected* to the ECU during this measurement. This may require some creativity in attaching a multimeter probe, but it will yield the most accurate measurement. A short length of uninsulated wire temporarily placed between the clamp and ECU connections may help.

While measuring the green wire with the voltmeter, use a small screwdriver to turn the adjustment screw on the side of the O_2 clamp. Rotating clockwise increases the voltage (making the simulated signal appear less lean) while rotating counterclockwise decreases the voltage (making the simulated signal appear more lean). The adjustment screw has 25 turns of travel, so it may be necessary to rotate it by more than one turn. If you do not see the voltage changing, stop. It is likely that the clamp is not energized or triggered. Find and correct this problem.

You may find it necessary to adjust this setting more than once to find the "sweet spot" for your car. If you find that, despite proper I/J adjust tuning, the vehicle tends to experience a brief lean spike when transitioning into boost, then decrease the voltage of the clamp. If you find that the vehicle tends to go overly rich and bog down, then increase the voltage of the clamp. At no time should the voltage be set to greater than 0.45 volts, nor lower than 0.15 volts. Lower voltages may cause a Check Engine light, while higher voltages will defeat the operation of the clamp.

If you are having trouble adjusting the clamp within these parameters, you probably need to step back and re-evaluate your fuel adjustment. Your injector setups need to be pretty closely dialed in before you can start worrying about this sort of thing. Remember, this device is intended only to correct leaning at the tip-in to boost, not to address overall lean or rich conditions.

Guarantee

I guarantee that this device is made of matter, that it has mass, and that it occupies space. I also guarantee that when correctly installed as indicated herein it will make a slight clicking noise when triggered, and alternate between passing the blue wire or an internally generated voltage to the green wire.

No guarantees of any kind are made concerning the applicability or suitability of this device to any particular application. You are, by definition, screwing with an engine management system that a bunch of highly skilled engineers spent a lot of time getting right, and unlike those folks, you don't have a Ph.D in electrical or mechanical engineering.

This device shall not be used on any pollution-controlled motor vehicle. If the state of California finds out that you installed one of these on your car, Governor Schwarzenegger will come into your home in the middle of the night, steal your car, kick your dog, and probably erase all the illegally downloaded music off of your iPod.

Prost.

- Joe Perez