NTK AIR Fuel Ratio Monitor

Gen2

MANUAL

Rev. 1.0

WARNINGS

This instruction manual explains the guidelines and warnings for operating and installing the Air Fuel Ratio Monitor (AFRM). Please make sure you fully understand the product and its intended use (see Introduction section). Please understand that we do not take responsibility for damages when the AFRM is used improperly, or in non-intended applications or conditions.

This product and its components may be changed to improve without notice.

Before initial use, please use care when routing and installing associated wiring, as failure to do so may cause a fire. Melted or damaged wiring will not be covered under warranty.

Use caution when working around rotating parts, such as the cooling fans, and hot surfaces, such as the exhaust and the sensor included in the kit.

Please use extreme care when handling the Wideband sensor, as it gets hot very fast. Also, keep the sensor away from combustible materials, as the sensor may ignite them.

When choosing a mounting location for the AFRM, caution should be taken as to not mount the AFRM in any location that will obstruct vision or compromise safety devices, such as airbags.

Please avoid placing the AFRM in direct sunshine, or in high temperature. Take care to avoid exposure to water, as these conditions may lead to failure.

Care should be taken when handling the AFRM, as dropping or mishandling it could cause serious damage to the unit. To ensure proper performance, please torque the sensor hand-tight, followed by 1/3~1/2 turn.

This product is only intended for applications that would use a range of **12VDC-16VDC**

Please use extreme caution when operating a vehicle while the AFRM is in use. Consult laws applicable in your area for use while driving.

NGK Spark Plugs does not accept any responsibility for incurred damage as a result of tuning, or in use failure with the AFRM.

Do not replace the fuse in the harness with a different amperage fuse. Use of a different amperage fuse may result in fire and/or system damage. Care should be taken to prevent fuse holder from being exposed to water.

Care should be used when disconnecting the electrical connector. Do not pull from the wire, as damage to the harness or system may result. Mishandling may also lead to electrical shock or fire.

If a switched installation is desired, be sure to connect the power cable (red 12v) at the ACC position. System voltage must be 0V at the OFF position.

NGK Spark Plugs shall not be liable for damage to interior mounting location of the AFRM.

Care should be taken not to reuse the included double stick tape, as adhesive properties will be weakened.

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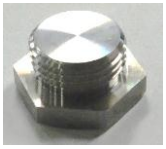
1. Introduction

The NTK AIR Fuel Ratio Monitor (AFRM) is a tool to measure the air-fuel ratio (AFR) produced by carbureted and fuel-injected performance engines. Its measurement range is 9.00 to 20.00 AFR for gasoline. This range equates to 0.62 to 1.37 λ (Lambda). For maximum sensor life, the sensor must be between powered and on when in the exhaust of a running engine.

2. Kit Contents

A/F Ratio Monitor×1	UEGO Sensor×1	Wiring Harness×1
		
Sensor Boss×1	Sensor Plug×1	Hook and Loop Fastener×1
		

3. Installation

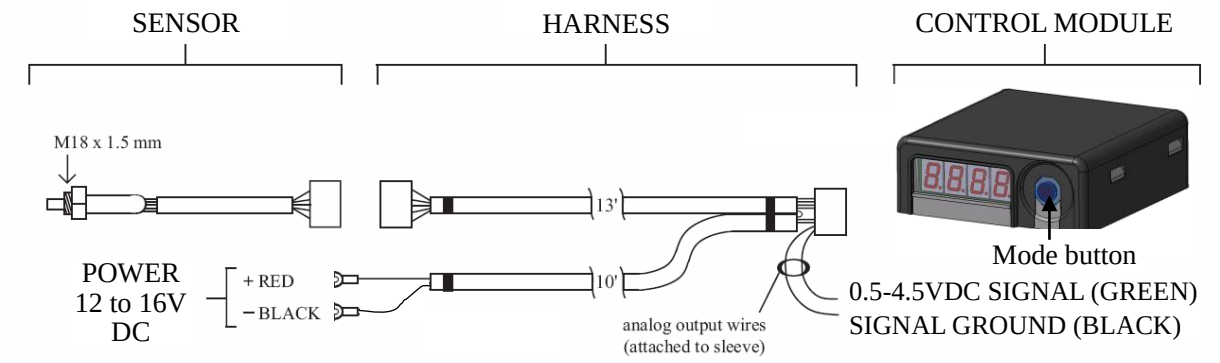
3-1. Wiring Notes

1. The AFRM considers the point where the BLACK wire connects to ground as the 0 (zero) volt reference point.
2. When utilizing the analog output feature of the AFRM, always be sure to connect the system ground (BLACK wire) to the same location as the analog SIGNAL GROUND (BLACK wire). The analog output wires (GREEN, BLACK) may be lengthened, as long as the appropriate gauge wire is used and the connection is solid.
3. It is advised to connect the system ground (BLACK wire) directly to battery ground or as close to this point as possible, or else a shift in the ground level of the analog output SIGNAL GROUND (BLACK wire) and any device linked to the analog output (data acquisition or engine controller) will receive an incorrect signal.
4. The RED wire is for system power positive (+). It is acceptable to route this wire through a fuse and/or relay where needed. The wire may be lengthened as long as the appropriate gauge wire is used and the connection is solid.
5. The AFRM requires approximately 3A for one minute at start-up and after that, requires

less than 1.5A for continuous operation.

6. The AFRM can operate on any DC supply voltage between 12VDC ~ 16VDC. If the power supply to the AFRM drops below 12VDC for even a short time, i.e. during cranking, the AFRM will reset itself. Maintain the supply voltage above 12VDC; above 13VDC is ideal.
7. If the AFRM system constantly resets itself, the cause is most likely low supply voltage, excessive electrical noise from the ignition system, or an inadequate ground. Use a strong battery and route the wiring harness and controller away from ignition components.

AFRM SYSTEM
(See Notes Above)

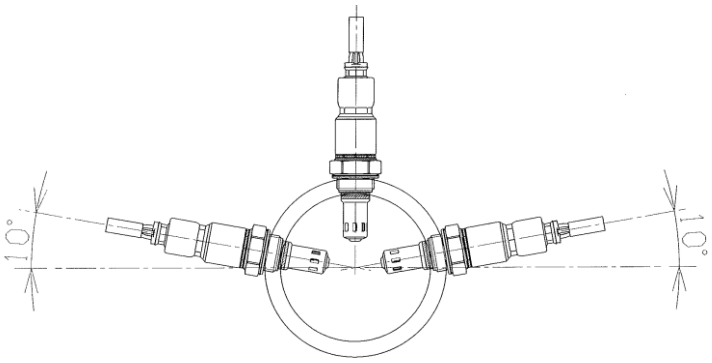


3-2. Sensor

Below are recommended guidelines for installing the sensor. Some exhaust configurations may make it difficult to meet each of the recommendations exactly, and some compromise in mounting may be required. The sensor does not necessarily have to precisely meet every mounting guideline below to operate, but please understand that the better you conform to these rules, the longer the sensor will last and the more accurate the results.

The AFR sensor should be located between 12” and 48” from the engine, upstream of any catalyst device, if equipped. The closer the sensor is to the engine, the more likely it will be to overheat, possibly shortening its life. The farther it is from the engine, the more likely condensed water will get into the sensor and thermally shock it, ultimately shortening its lifespan. Installing the sensor too far away from the engine may also lead to poisoning of the sensor via carbon or fuel.

Make sure there are no leaks in the exhaust system, as this will create an artificially lean (higher) AFR reading. The sensor should be installed upstream of any factory air-injection, if equipped, otherwise, a false lean condition may occur.
In turbocharged applications, it is recommended that the sensor be installed at least 18” downstream of the turbine. This is due to the fact that high pressures before the turbine can distort the AFR reading.
The sensor boss requires you to drill a hole in the exhaust; a step drill or hole saw may be used. Weld the sensor boss to the exhaust so that it will position the sensor in the upper half of the exhaust, ideally between the 10 o’clock and 2 o’clock locations (see diagram below). This is to avoid liquid fuel or condensation from getting inside the sensor and thermally shocking it.



After welding the sensor boss to the exhaust, run an M18 x 1.5mm tap or thread cleaner (KD Tool P/N 730 or equivalent) through the boss to remove any thread-distortion. If this is not done, the sensor's threads may be damaged during installation or removal. Apply a small amount of anti-seize compound to the threads and tighten the sensor to 45~55N·m.(Previously stated as 1/3~1/2 turn)
Caution must be taken as to not over-tighten the sensor. Unless you are permanently installing the unit as a constant AFR monitoring device, you will be installing and removing the sensor frequently.

During reinstallation, if the sensor shows any resistance to being screwed back into the boss, run the tap or thread-cleaner through the boss, clean the threads of the sensor with a fine-wire brush, and apply a small amount of anti-seize to the threads before installation. If the threads on the sensor are damaged, run the sensor through a die.

The controller has an operating temperature range of -40º to 158º F (-40º to 70º C) and is not waterproof. Mount it accordingly. The controller and the harness should be kept away from ignition systems and the harness should be routed away from the exhaust system and moving engine components.

The quality of the AFR measurement depends on the quality of the power you supply to the AFRM. The ground terminal (BLACK wire) should be connected directly to the battery's negative terminal or the body of the vehicle (if metal). Supplying power and ground through a vehicle's cigarette lighter is not recommended. The power terminal (RED wire) should have 12 to 16V DC attached (via a switch or relay) whenever the engine is running. If the sensor is not powered when the engine is running, sensor life will be shortened. The AFRM (including sensor) draws less than 2 amps after start-up.
Before the AFRM is used for the first time, or for the first time a new sensor is used, it should be calibrated (see next section).

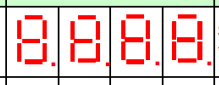
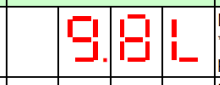
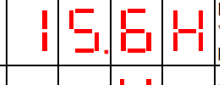
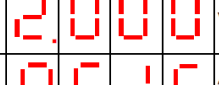
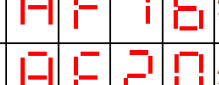
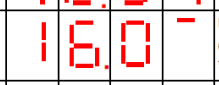
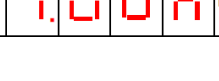
4. Operation

4-1. Basic Operation

The Mode Button is only used for A/F meter operations or calibration.

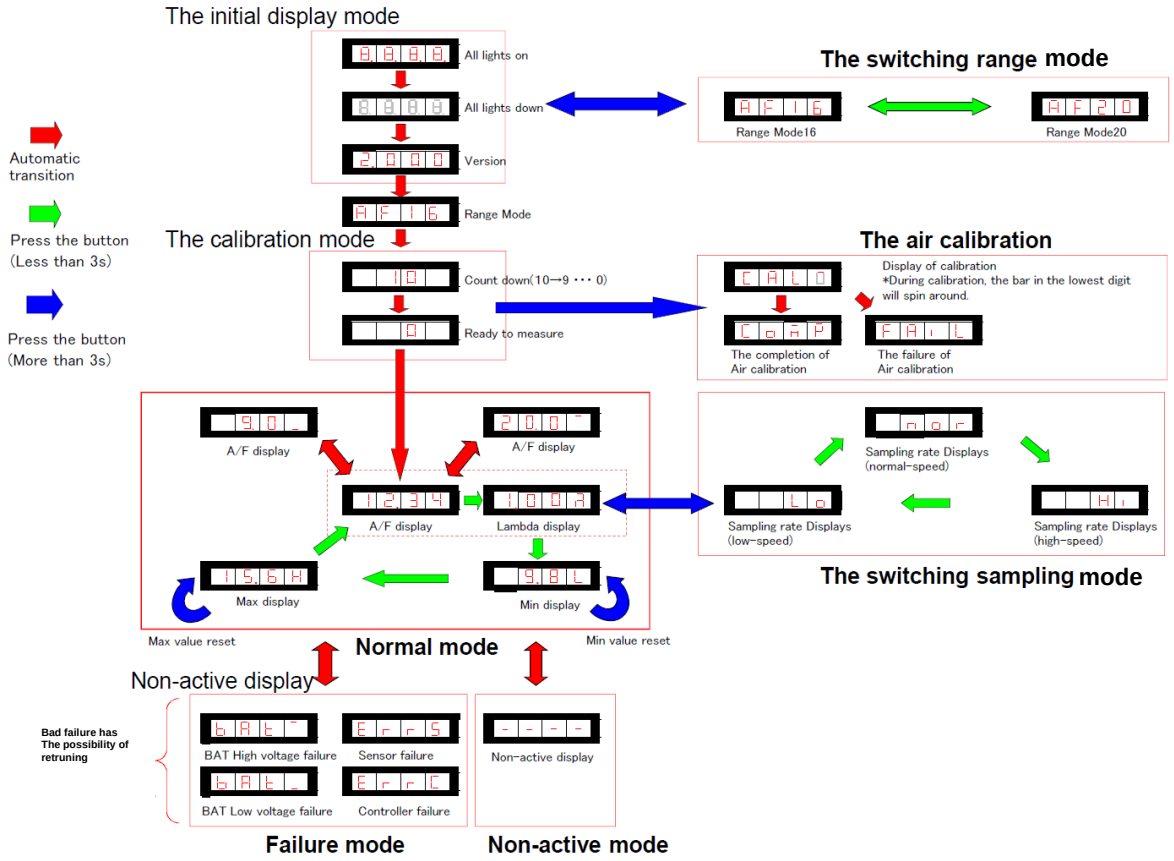
The Mode button involves two types of functions: long press (more than three seconds) for free-air calibration, and normal press for switching of the LED display.

4-2. Display Functions

	Displayed 7SEG pattern(4digit)	Meaning		Displayed 7SEG pattern(4digit)	Meaning
1		Startup check *All lights	13		Minimum Air Fuel Ratio of the trip *2 digits of integral part. 1 digit of decimal part.
2		Startup check *All lights down	14		Maximum Air Fuel Ratio of the trip *2 digits of integral part. 1 digit of decimal part.
3		Version	15		Sampling rate (High speed) *Samples every 50ms
4		Air Fuel Ratio Range Mode16 *Values from 9 to 16 can be displayed.	16		Sampling rate (Standard speed) *Samples every 100ms
5		Air Fuel Ratio Range Mode20 *Values from 9 to 20 can be displayed.	17		Sampling rate (Low speed) *Samples every 250ms
6		Available for atmospheric correction *Count down for 10 sec	18		Calibrating *The bar in the lowest digit will spin around.
7		Air Fuel Ratio *2 digits of Integral part, 2 digits of decimal part. Values from 9 to 20 can be displayed, but values under 9 and over 20 cannot be displayed.	19		Succeeded atmospheric correction
8		Upper Limit of measurable Air Fuel Ratio (Mode16). *Actual Air Fuel Ratio may be above the limit.	20		Failed atmospheric correction
9		Upper Limit of measurable Air Fuel Ratio (Mode20). *Actual Air Fuel Ratio may be above the limit.	21		Abnormal high voltage from battery. *Over 16 Volts
10		Lower Limit of measurable Air Fuel Ratio. *Actual Air Fuel Ratio may be below the limit.	22		Abnormal low voltage from battery. *Under 11 Volts
11		Non active	23		Sensor failure *Sensor or sensor wiring malfunctioned.
12		Lambda	24		Controller failure *Internal controller malfunctioned.

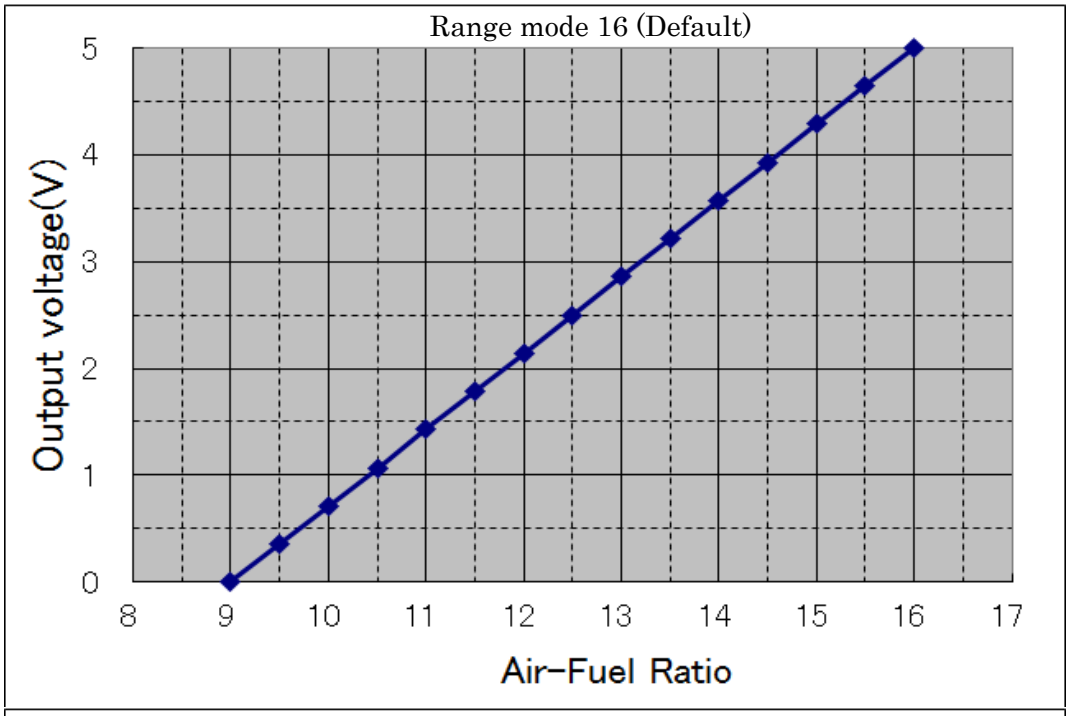
4-3. LED Display Changes and Button Operation

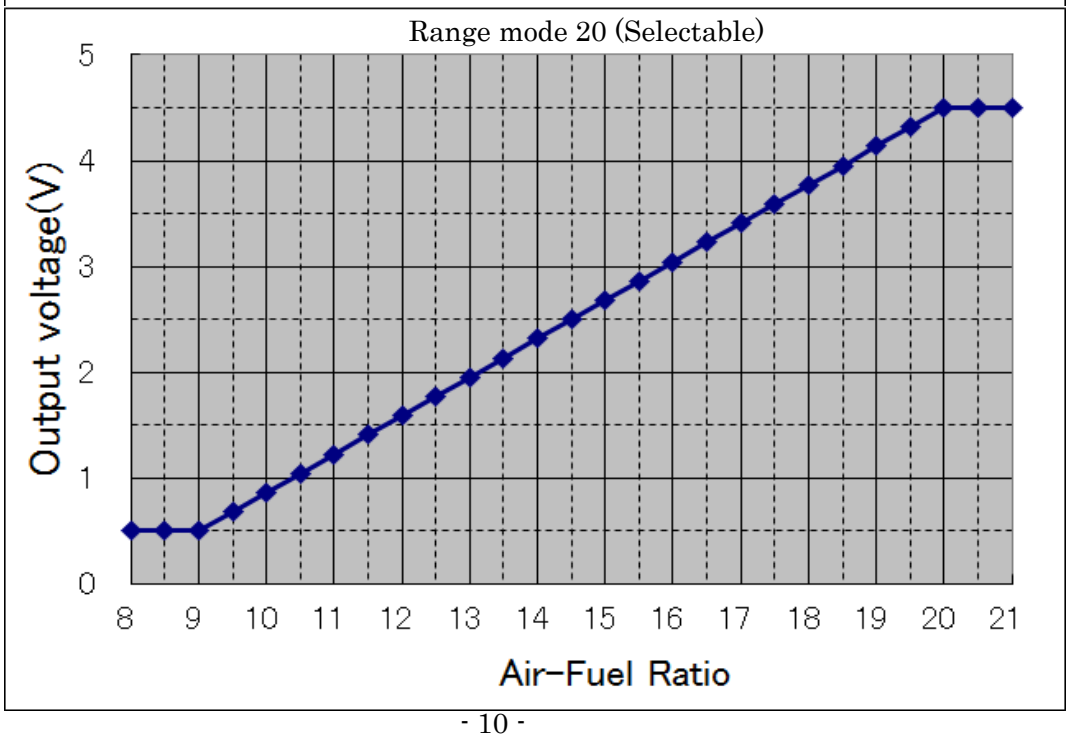
LED display changes and button operation are as follows.



4-4. Analog Output

Use this information to input to an engine controller or data acquisition system. The analog output signal wire is GREEN and is attached to terminal position 4 of the connector that plugs into the controller. The analog output ground wire is BLACK and is attached to terminal position 9 of the same connector. The output wires are each 12" long and are attached to the mesh sleeve. To access the wires, gently separate them from the mesh sleeve. There are two selectable output modes: AF16 and AF20. The default mode is AF16, where 0V is 9.00:1AFR, 5V is 16.00:1AFR, and free air will be a fixed 5V output. On the other hand, the alternative mode is AF20, where 0.5V is 9.00:1AFR, 4.5V is 20.00:1AFR, and free air will be a fixed 4.5V output.





5. Calibration

The procedure to calibrate the AFRM is as follows:

1. Connect the harness to the control module and the AFR sensor. With power disconnected from the harness and the sensor removed from the exhaust, let the sensor hang free in the air. One cannot efficiently calibrate the AFRM with the sensor mounted in the exhaust of an engine, even if the engine has been off for several days.
2. Power-up the system and energize it for more than 60 seconds, then turn off.
3. Power- up again, Press the Mode button for more than three seconds, until you see "CAL¯."
4. At this point, the LED display will read "ConP." This indicates that the free air calibration was successful. Please shut down the A / F meter (turn off the power).

*If the display reads "FaiL," short for "Failed atmospheric correction," repeat the calibration process and ensure the controller has 12VDC-16 VDC. Please make sure that it carried out at normal conditions, outside of the exhaust and has adequate voltage to the controller.

5. Disconnect the power from the harness. After the sensor has cooled, install it in the exhaust and do not touch the mode button until the next time you calibrate the AFRM, unless toggling LED displays.
   It is impossible to predict how often the AFRM needs to be calibrated without knowing the conditions under which the sensor was used. However, here are some calibration guidelines:

   • The first time before a new sensor is used: calibrate
   • For every 3000 ft. change in altitude: calibrate
   • For race engines: calibrate before every tune session
   • For continuous use with leaded fuel: calibrate once every hour

The AFRM has been designed to extend the sensor's life as long as possible. However, because the sensor's life depends on sensor operating conditions, it impossible to predict the sensor's life without knowing the conditions under which the sensor was used. Certainly, leaded fuel will shorten the sensor's life. Please note, there are various elements or conditions that can cause sensor failure. For example, a spark plug may foul and the sensor may be sprayed with raw fuel and thus be thermally shocked. Therefore, the sensor should be considered an expendable part; a cost of tuning, just like gasoline and your time. Some tuners will never kill a sensor. Some tuners will kill two sensors a race season. This will depend on many variables, therefore, there is no service interval or expected life cycle.
You may use the AFRM as a constant AFR monitoring tool, but keep in mind that this will consume the sensor faster. If you are not using the sensor to tune the engine, we generally recommend you take it out. It may be a good idea to keep a backup sensor on-hand if you tune frequently, or if you tune at the track.

6. Compatible Fuels

The AFRM is compatible with fuels other than gasoline. The AFRM's display is designed to show AFR values based on a gasoline scale with 14.7:1 AFR as the stoichiometric ratio. The display will simply show AFR on a gasoline scale even though the fuel used may have different properties (stoichiometry for methanol is approximately 6.5:1). As long as you understand this, interpreting the values should be fairly easy.

The same principle applies to other fuels such as ethanol, propane, CNG, LPG, etc. The display will simply read on a gasoline scale.

The AFRM will also work with diesel fuel. However, due to the nature of diesel engines generally running lean by design, you may experience a problem with the limits of range with the AFRM. The AFRM has a lean limit of 20.00:1 AFR (or approximately 1.37 λ) in case of Range mode 20 (AF20), and many diesel engines run leaner than this.

As long as the engine runs between the range of 9.00:1 ~ 20.00:1 AFR (or 0.62 to 1.37 λ), the AFRM will work with almost any fuel type.

Conversion factors for the more commonly used fuels:

	AF16 (Default)	**AF20 (Selectable)**
Gasoline AFR	**= V_{OUT} x 1.4 + 9**	**= {(V_{OUT} - 0.5) x 2.75} + 9**
Methanol AFR	**= V_{OUT} x 0.62 + 3.96**	**= {(V_{OUT} - 0.5) x 1.21} + 3.96**

Lambda (λ) is a universal unit of measurement for AFR, regardless of fuel. A Lambda value of 1 = stoichiometry. Lambda is derived by dividing the actual AFR by the stoichiometric AFR for that specific fuel type. For example, stoichiometry for gasoline is 14.55:1 AFR. A gasoline engine running at 12.5:1 AFR means that it is at 0.86 Lambda (divide 12.5 by 14.55).

	AF16 (Default)	**AF20 (Selectable)**
Lambda	**= V_{OUT} x 0.097 + 0.62**	**{(V_{OUT}-0.5) x 0.189)} + 0.62**

7. Troubleshooting

• If you cannot calibrate the AFRM or if the display shows "ErrS," meaning "Error Sensor," or "ErrC," meaning "Error Controller," you should:

1. Check if the sensor is attached
2. Check if the wiring harness is damaged
3. If steps 1 and 2 show no problems, replace the AFR sensor, as it has reached its limit for useful life.
4. Contact NGK Spark Plugs for additional information.

• If the display shows "Bat_," the supply voltage is too low (below 11V).
• If the display shows "Bat¯," the supply voltage is too high (above 16V).

• If the display shows “9.0_,” the AFR is 9.00 or less.
• If the display shows “20.0¯,” the AFR is 20.00 or more.

8. Specifications

Product Name	NTK AIR Fuel Ratio Monitor
Part # Stock #	VTA0001-WW002 90067
Function	Linear engine air-fuel ratio (AFR) monitor
Application	4-stroke or 4-cycle engines
Measurable AFR Range	9.00:1 ~ 16.00:1 AFR
	Equivalent to 0.62 ~ 1.1 λ (Lambda)
	9.00:1 ~ 20.00:1 AFR
	Equivalent to 0.62 ~ 1.37 λ (Lambda)
Dimensions	Controller dimensions (excluding protrusions): 65 x 63 x 23 mm
	Controller weight: 60g
	Wiring Harness length: Sensor side 13 ft. Power side 10 ft.
Supply Voltage	DC 12VDC ~ 16VDC
Sensor-Tightening Torque	45 ~ 55 N·m
Controller Temperature Tolerance	-40º to 158º F (-40º to 70º C)
Maximum Exhaust Temperature	1650º F (900º C)
Compatible Fuel Types	Gasoline (leaded or unleaded), alcohol (methanol), ethanol, CNG, LPG, propane
Fuse Specification	φ6.4×30, Rated Voltage:DC32V, Ampere Rating:8A
Electromagnetic Compatibility	CE EN50498:2010

9. Product Warranty

NGK Spark Plugs warrant that the products, which it sells to the distributor, seller, reseller, or customer, shall be free from defects in workmanship and materials within a period of sixty (60) days from the delivery thereof to the aforementioned parties. This does not apply to products that have been modified, altered, abused, damaged during transit, or subjected to conditions in excess of their intended environment. Due to the nature of the product, there is no warranty on sensor life.

NGK Spark Plugs (U.S.A.), Inc. Shall not be liable for any economic damages or losses resulting from the improper use of its products.

This warranty is valid only in the U.S.A. & South Africa.