

# R1100S/R1150

## Lambdgrayifter 2.0 On the Air (OTA)

### handling instructions

12/05/2022

V2.0



legend



#### Attention!

Describe possible damage to the vehicle or device.



#### information

Describe precautions related to the normal operation of the device.

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## 1. Feature

This device is intended for Moronic 2.4 ECUs equipped with a narrowband O2 sensor to adjust fuel in the cruise range at low-mid RPM and low load to improve driving characteristics. In the stock condition, the closed-loop air-fuel ratio is fixed at 14.7 to comply with environmental regulations. With this device, it can be set richer to about 13.7.

The benefits of making it richer are as follows

- Idling stability
- Improved mid- to low-speed torque
- Improved throttle response in cruising range
- Decrease in engine temperature

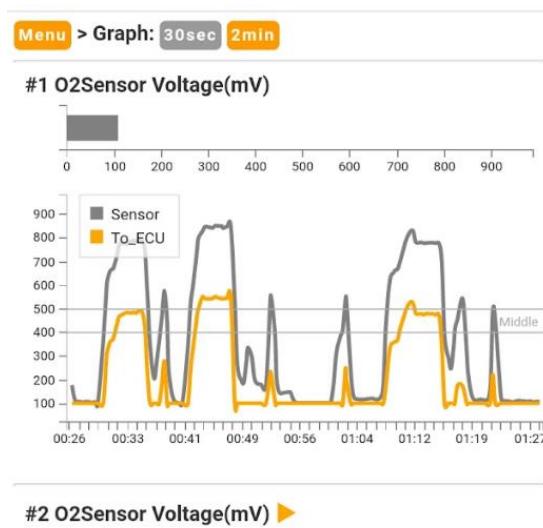
All other functions of the device can be controlled by a smartphone or other wireless LAN-compatible device.

**Lambda Shifter**  
OTA ver2.0

<- Click to reload.

Item	Current	Action
Realtime Graph	-	<b>30sec</b> <b>2min</b>
Logging *Limit: 180min.	<b>ON</b>	<b>Switch</b> / <b>Download</b>
Shift_Voltage (V:AFR)	<b>0.20</b>	<b>SET</b> <input type="button" value="0.20:15.1 ▾"/>
ECU MAP *Option *After set turn off/on kill-switch.	<b>MAP3</b>	<b>SET</b> <input type="button" value="MAP3 ▾"/>
WiFi Mode	<b>Client</b>	<b>Edit</b>
Firm / File Version	<b>2.0.8 / 2.0.5</b>	<b>Update</b>

\*Values for "Shift\_Voltage" and "ECU MAP" are stored in the device.  
\*Device logs are saved when "ON" and can be downloaded afterwards.



Refer to the following documents for closed-loop and open-loop ECU control and ignition timing adjustments.

### English version

<https://drive.google.com/file/d/1yzwXpZE8MO3YYsV9nFuAE6dRmlb3xPf2/view?usp=sharing>

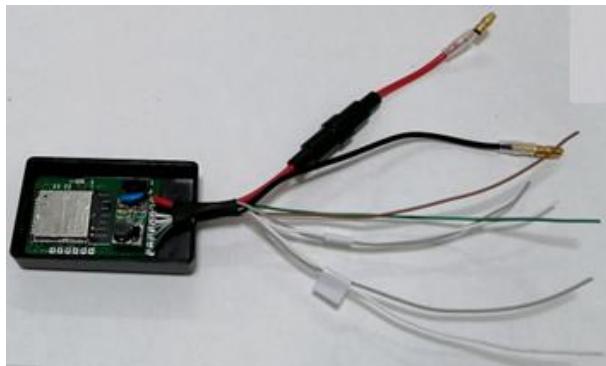
### Japanese (language) version

<https://drive.google.com/file/d/17E6WIj0e4-W8HM2w7mWsXGhC5LxRpZlZ/view?usp=sharing>

This device and software are released under the MIT License. For details, see "Appendix: Development Resources and Development Environment" and "Appendix: License Information".

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## 2. Specification



Device internal



Connectors, etc

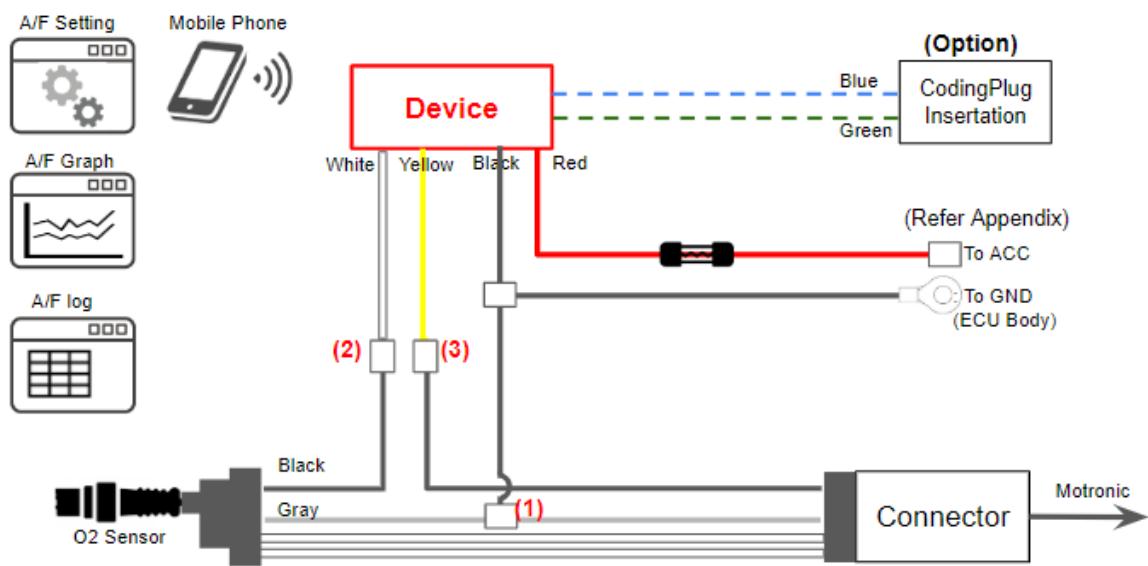
(data) item	Contents
<b>Size (mm)</b>	58 × 36 × 16
<b>weight</b>	40g(including cable)
<b>Supply voltage</b>	9v to 20v
<b>Operating temperature range</b>	-20 to 80°C
<b>Power consumption</b>	Average 80mA Maximum 500mA
<b>Waterproof level</b>	Waterproof for life
<b>Number of input sensors</b>	2
<b>Sensor input range (error)</b>	100 to 1000mV ( $\pm 1\%$ )
<b>Voltage output range (error)</b>	100 to 900mV ( $\pm 1\%$ )
<b>Wi-Fi</b>	802.11 b/g/n (HT40)
<b>Supported Browsers</b>	Google Chrome 56 or later
<b>Recommend Display Size</b>	Above 400px × 800px

## 3. Install

### 3.1 Device

Referring to the wiring diagram, connect the O2 sensor to the power supply and install the device in the appropriate location.

Connection to coding plug is an option for ECU chip connection switching.



### 3.2 Body

- Connect the power supply (red/black) of the device referring to the wiring diagram and Appendix.
- Connect an electro-tap to the gray cable of the sensor and connect it to the black of the device\*(1)
- Disconnect the black cable of the O2 sensor from the stock O2 sensor and connect the O2 sensor side to the white side of the device. \*(2)
- Connect the black cable of the vehicle body side to the yellow cable of the device. (3)  
Connect the black cable to the yellow cable of the device.
- Use a flat type (250 type) terminal to insert into the coding plug. Fix the cable so that it will not come loose.

### 3.3 Device cable color and connection destination

Device Cable Color	access point	(Reference) Internal connection pins
red	12v(ACC)	2(VIN+)
Black	Grounding of the vehicle body. Negative battery terminal recommended.	1(GND)
white	Black cable of O2 sensor. Sensor side	35
gray	Black cable of O2 sensor. Body side	25
brown	No. 86 terminal of coding plug	18
green	No. 87 terminal of coding plug	19



#### Attention!

- Install in a location near the O2 sensor and that meets the specifications at the time of use.  
ex) No direct exposure to rain. No direct heat transfer from the engine.
- Do not connect the power supply in reverse. The fuse will blow or internal power supply parts will be damaged.  
If damaged, the device must be disassembled and either the fuse, regulator, or diode replaced.
- Do not short-circuit the power supply and the white/gray/brown/green cable. The chip inside the device will be damaged.  
Discontinue use and remove the device if there is a possibility of internal chip damage due to possible heat generation.
- Do not short-circuit the cables of the device to each other or to metal parts of the car body while the power is turned on.

## 4. WiFi Connection

This device provides two Wi-Fi connection methods.

### 4.1 AP mode

Initial state of this device. The device is made an access point and connected from the smartphone side.

The settings are listed on the face of this device. Settings cannot be changed.



\*Example of WiFi connection information for devices, connection direction

- (1) Turn on the power to the vehicle and connect to the device's SSID with a smartphone or other device.
- (2) Open browser and. Access <http://10.1.1.1/> The menu of this device is displayed..  
→ If you cannot connect, turn off the mobile line.

A screenshot of a web-based configuration interface for the Lambda Shifter. At the top, it says "Lambda Shifter OTA ver2.0" and "Click to reload.". Below is a table with the following data:

Item	Current	Action
Realtime Graph	-	30sec   2min
Logging *Limit: 180min.	OFF	Switch / Download
Shift_Voltage (V:AFR)	Disable	SET [Disable ▾]
ECU MAP *Option *After set turn off/on kill-switch.	MAP1	SET [MAP1 ▾]
WiFi Mode	Client	Edit
Firm / File Version	2.0.8 / 2.0.5	Update

\*Values for "Shift\_Voltage" and "ECU MAP" are stored in the device.  
\*Device logs are saved when "ON" and can be downloaded afterwards.

Every time the device is turned on, WiFi reconnection is required. In addition, there are some models that cannot use a mobile connection at the same time.

The following client modes allow simultaneous use of WiFi reconnection-free and mobile lines.

## 4.2 Client mode

Connect to the smartphone from the device side using the smartphone's tethering function.



- (1) Connect to the device in AP mode.
- (2) Click "WiFi Mode" on the menu, then "Edit".



- (3) Enter the SSID, password, IP address, and gateway for tethering on your smartphone

**Menu** > WiFi Client settings

Item	Contents
Status	WiFi:OK / Gateway:OK / Internet:OK
SSID	TEST-SSID001
Password	Password1234 <span>Hide</span>
Device IP address	192.168.43.100
Subnet Mask	255.255.255.0
Gateway Address	192.168.43.1
Action	<b>SET(Restart)</b>

\*These settings are for connecting from a device to a mobile phone or other device.  
\*If you do not know the connection destination setting, DO NOT CHANGE.

Parameter	Android	iPhone
SSID	Adapt to Smartphones	Adapt to Smartphones
Password	Adapt to Smartphones	Adapt to Smartphones
IP	192.168.43.10	172.20.10.5
Subnet	255.255.255.0	255.255.255.240
Gateway	192.168.43.1	172.20.10.1

\*Setting example. Separate investigation is required for some models.

- (4) click the "Set(Restart)" button.

- (5) After activating tethering on your smartphone, turn on the ignition.

- (6) Go to [http://\[ip set for device\]/](http://[ip set for device]/).

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→The menu of this device will be displayed.

From the next time onward, only steps (5) and (6) need to be performed to connect to the device.

## information

### If the menu is not displayed

Turn off tethering on the smartphone, turn off/on the device, and then reconnect in AP mode.

Check the Status of Wi-Fi Setting and modify the settings as follows.

Wi-Fi: **NG**

SSID or password is incorrect.

Wi-Fi: **OK** Gateway: **NG**

Incorrect IP or gateway settings.

Reference: Wi-Fi: **OK** Gateway: **OK** Internet: **NG**

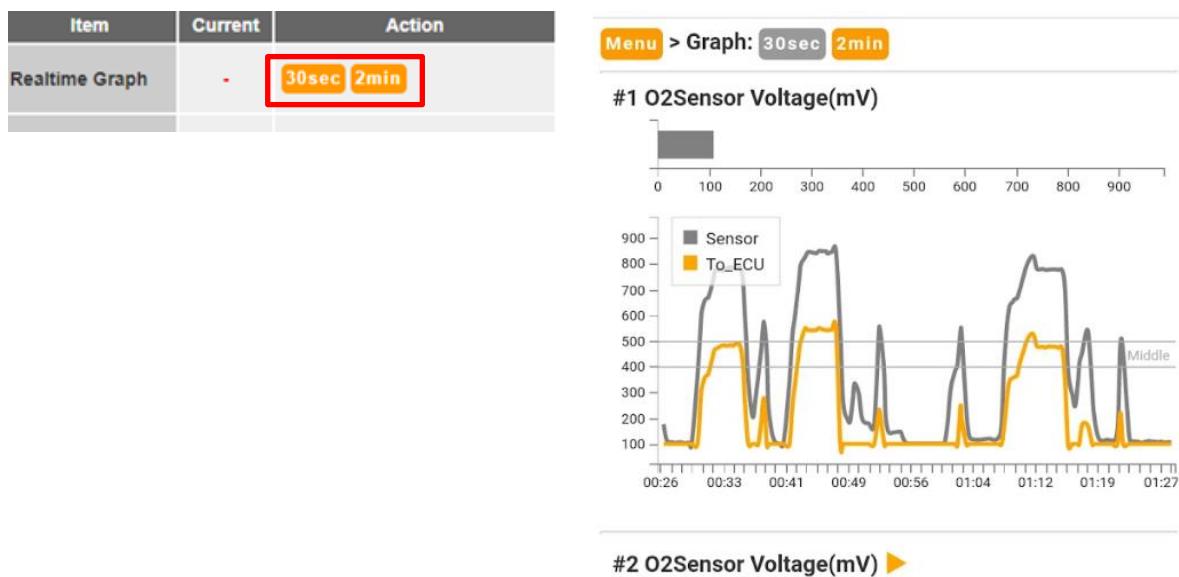
Device connection is normal. Smartphone is not connected to the Internet.

## 5. Device Operation

This device is operated entirely via smartphone or PC. The operation methods are as follows

### 5.1 Realtime Graph

By selecting "30sec" or "2min" in the Realtime Graph line of the menu, the sensor voltage input/output of the device can be checked in real time.



The gray bars and lines are inputs to the O2 sensor and the orange lines are outputs to the ECU.

When the orange line is below 400 mv, the ECU determines that the fuel is lean; when it is above 500 mv, the ECU determines that the fuel is rich.

If two O2 sensors are connected, the second graph can be displayed by selecting "▼".

#### information

The characteristics of the narrow band O2 sensor are as follows

- Normal is a state of constantly going back and forth between rich and lean. See "Appendix O2 Sensor Specifications" for details.
- When cold (oil temperature/water temperature below 60°C), it becomes thicker.
- When idling and cruising, it goes back and forth between a thick/thin state.
- The dark state continues when the accelerator pedal is opened wide.
- When the accelerator is closed above 2000 rpm, the fuel cutoff results in a thin state.
- If the above operation does not occur even when the engine is warm, check the O2 sensor by referring to the "Appendix Operation Checklist".

## 5.2 Logging

Tap "Switch" in the Logging row to toggle the status on and off.

Logs are recorded in the "ON" stabrownnd logs in CSV format are downloaded by tapping "Download" at the appropriate timing.

Item	Current	Action
Realtime Graph	-	30sec 2min
Logging *Limit: 180min.	ON	Switch / Download
Shift_Voltage	0.20	SET [0.20-15.1 ▾]



### information

- The file should be downloaded before the ignition is turned off. Logs are deleted when the device is turned off.
- If the logs exceed the device's storage limit, access will be disabled from smartphones.

### 5.3 Shift Voltage

This function changes the sensor voltage output to the ECU and adjusts the amount of fuel injection. Default is 14.7.

This setting value is saved in the device, so there is no need to display the setting screen each time.

In the "Shift Voltage" line, select the shift voltage (AFR). Tap "SET".

Shift_Voltage (V:AFR)	0.00	SET	0.00:14.7 ▾
ECU MAP *Option *After set turn off/on kill-switch.	MAP1	SET	0.00:14.7 -0.30:14.0 -0.20:14.3 -0.10:14.5 0.10:14.9 0.20:15.1 0.30:15.3 -0.37:13.7 Disable
WiFi Mode	Client	Edit	
Firm / File Version	2.0.8 / 0.0.5	Update	



#### information

The "Disable" mode outputs 0.45 V to the ECU regardless of the sensor input and turns off the closed loop.



#### Attention!

- If the air-fuel ratio is made lean, the oil temperature and plug burning should be monitored. Risk of engine blowout due to heating.
- If "-0.37 (13.7)" or "0.30 (15.3)" is selected, the error with the actual A/F ratio may be larger. This is because the stock narrow band O2 sensor is only intended to detect 14.7.
- Motronic 2.4 has a learning function that reflects the results of closed-loop trimming to the open loop. The reflection is usually completed after 200 to 300 km of driving.

## 5.4 ECU MAP (option)

Ability to switch ECU maps by connecting specific pins of the coding plug to GND.

This setting value is saved in the device, so there is no need to display the setting screen each time.

In the "ECU MAP" line, select a map. Tap "SET".



### Attention!

- This function assumes ECU map rewriting and coding plugs for BMW shipment region switching.
- See "Appendix 1" for map rewriting.

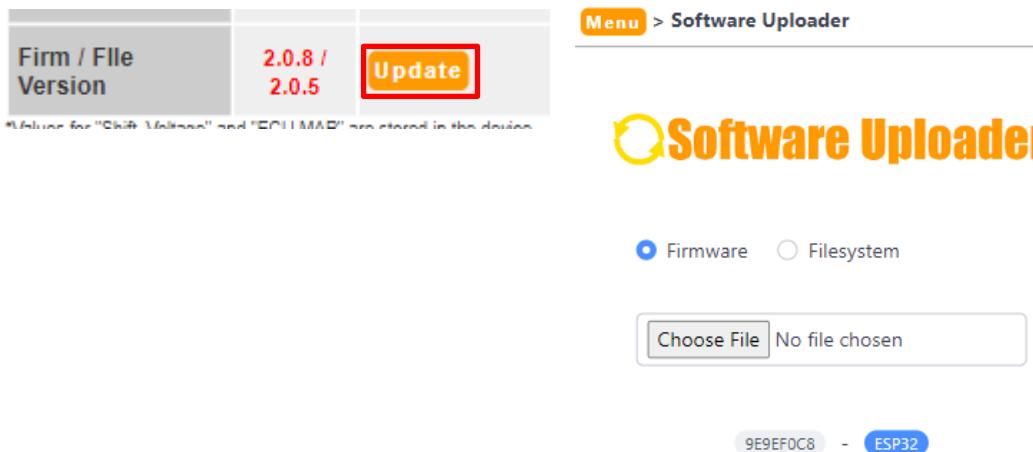
## 5.5 WiFi Mode

Refer to "4. How to connect to WiFi".

## 5.6 Firm/File Version

Displays the current firmware and web screen version. Clicking "Update" will take you to the firmware and file upload screen. This function is used to modify software, calibrate sensors, or add functions after installation.

Select "Firmware" when uploading "firmware.bin" and "Filesystem" when uploading "spiffs.bin".



### Attention!

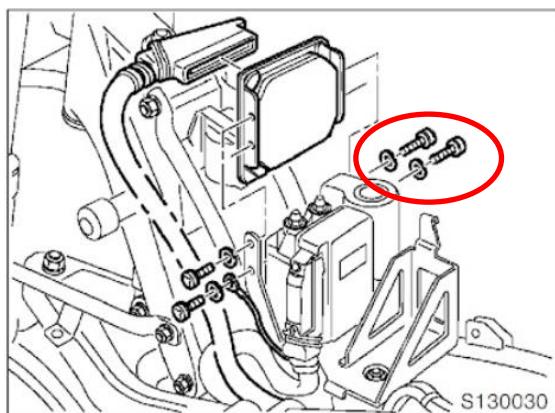
- Uploading should be done only when necessary as a result of an inquiry.
- Do not divert files from other devices, as firmware and file systems vary from device to device.
- Select the correct Firmware and Filesystem. If you make a mistake, you will need to re-upload the file again.

## 6. Appendix

### Appendix: Device Power Connection Example

#### Connection of GND and sensor gray

- The black cable of the device is connected to the GND of the car body and gray cable of the O2 sensor.
- The black cable of the device should be connected to the GND of the car body and the gray cable of the O2 sensor.
- Use an electro-tap for the O2 sensor gray cable. (Refer to "Electro-tap Connection Example" in this section.)



#### ACC power supply

Connect the red cable of the device to the ACC power supply of the car body. (See "Electro-tap Connection Example" in this section.)

The following is an example of interrupting the R1100S brake switch cable (yellow).



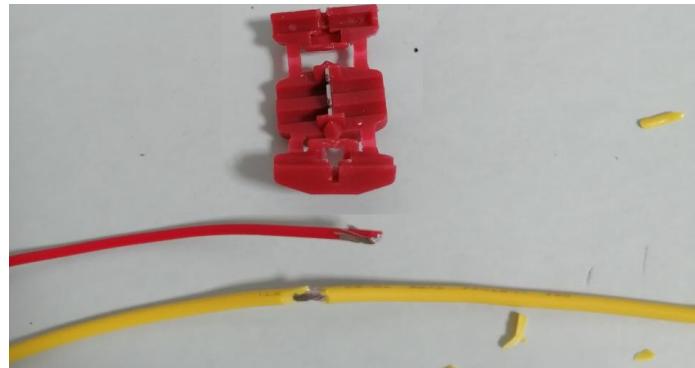
#### Attention!

- Electrotap must be used correctly. Poor contact may occur and the device may not operate properly.
- When obtaining GND and ACC power, check the wiring conditions beforehand using a tester or similar device. If the wiring condition is not correct, the device may not operate properly.

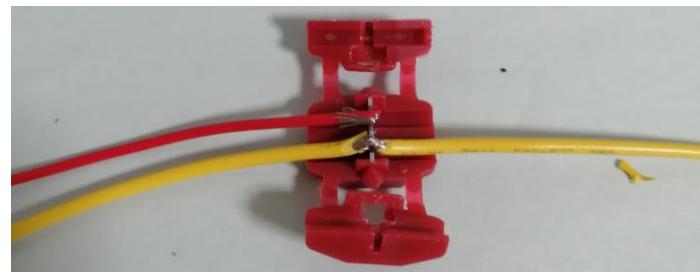
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### **Electro-tap connection example**

Use a cutter or similar tool to shave the sheath of the cable to be connected. The cable on the device side is folded back after shaving the sheath at the end.



Place the cable so that the wire part touches the metal part in the center of the ElectroTap as shown below.



Use pliers, etc., to clamp the ElectroTap until it snaps into place.



Cover the ElectroTap with vinyl wiring tape, etc.



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## Appendix: Installation on the R1200 series

The R1200 series has two O2 sensors, and the connector location and shape is different from the R1100S/R1150. The following is reference information based on actual installation.

### (1) Device installation location

There is no particular specification. Install the device in a location where it is easy to obtain grounding from the vehicle body and ACC power, and where it meets the device specifications.

### (2) Extension cable creation

The R1200 series O2 sensor connectors are located under the cylinder head, inside the cover, as shown below. There is one on each side.



Make white and yellow extension cables from the device (location for installation is for reference). Protect the extended cable with tubing or vinyl tape.

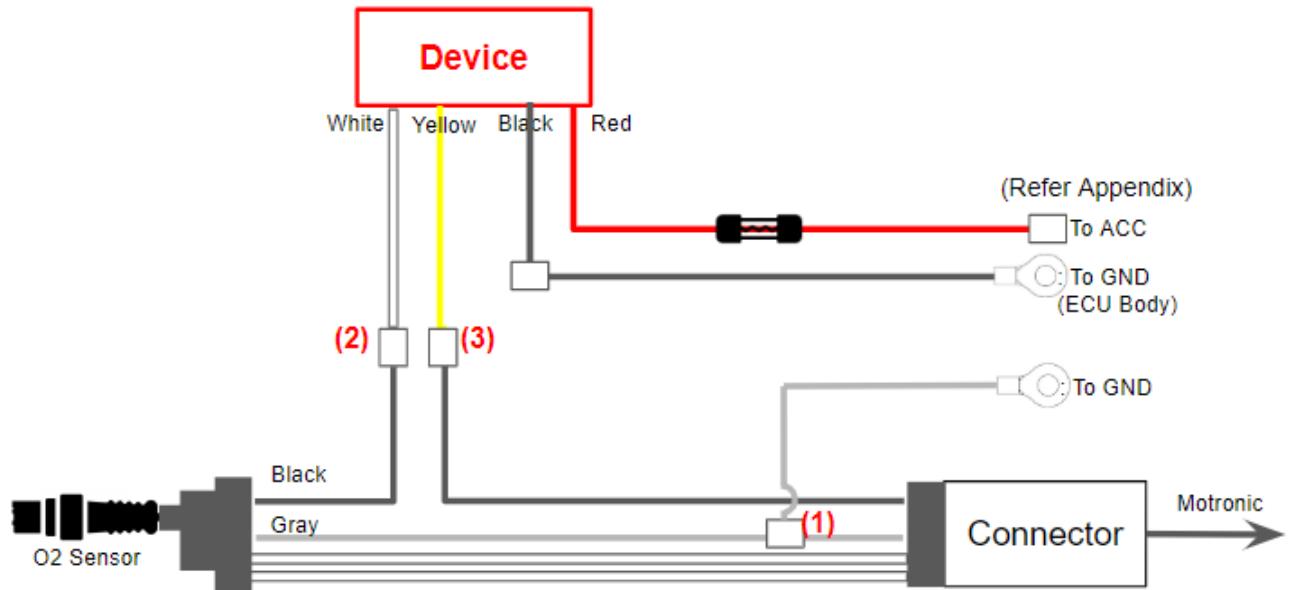
### (3) Connecting the O2 sensor connector to the device

The target connector has white, white, gray, and black cables as shown below.



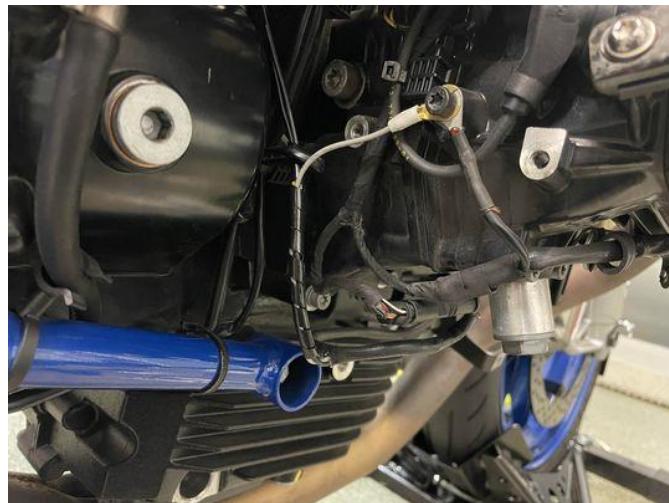
Connect the device to the cable on the connector side as shown in the figure below. The diagram omits the second sensor.

(The difference from the 1-sensor model is that there is no option and the gray cable connects to the vehicle body GND.)



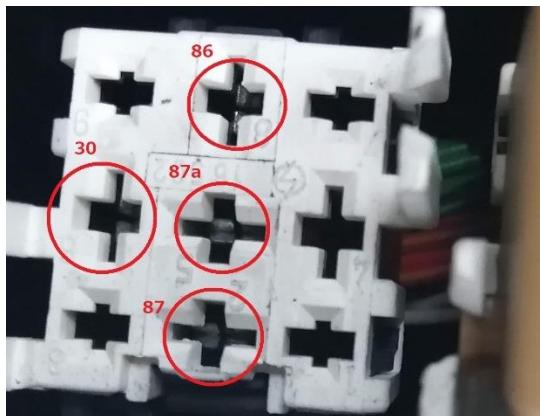
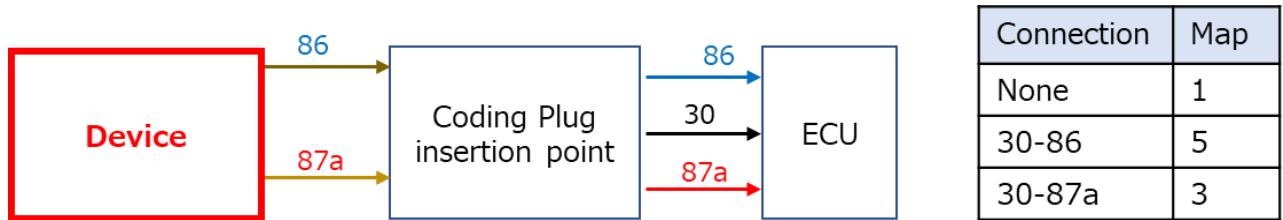
Wiring should be protected with tubing or vinyl tape.

Below is an example of the gray cable connection. Please check in advance that the connection point is grounded to the vehicle body.



## Appendix: Map Switching by Coding Plug

Flat terminals are attached to the brown and green cable ends of the device and connected to the coding plug insert on the car body to be used as a map switching switch for the ECU.



### information

- **(Important) Turn the ignition ON with the kill switch OFF, then turn the kill switch ON and start the engine.** Because the ECU needs to be reloaded to reflect the map.
- Since there is no significant difference in the stock map when switched, we recommend replacing the EPROM chip in the ECU. (Refer to "5.2. ECU Chip Replacement" and "Appendix 3 Switching Maps by Coding Plug" in the URL below.)

#### English version

<https://drive.google.com/file/d/1yzwXpZE8MO3YYsV9nFuAE6dRmlb3xPf2/view?usp=sharing>

#### Japanese (language) version

<https://drive.google.com/file/d/17E6WIj0e4-W8HM2w7mWsXGhC5LxRpZlZ/view?usp=sharing>

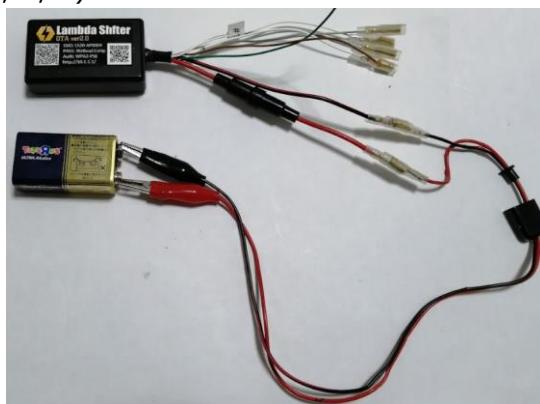
## Appendix: Operation Checklist

The stand-alone device is disconnected from the body of the vehicle, while the combined device is fully installed.

category	No		check	Cause / Remarks
frame	1	Use an ECU diagnostic tool such as GS911 to check for errors.		Resolve errors before device installation
	2	Disconnect the O2 sensor connector, attach a voltmeter to the pin on the body side, and check for the following voltages Black - Car body (GND): around 0.58v Gray to car body (GND): around 0.14v		If the voltage deviates significantly from the reference, ECU failure
	3	O2Heat the sensor to 800°C with a gas burner or the like, and see if there is a voltage of about 0.1-0.15v between the black and gray cables.		If it does not operate normally, O2 sensor is abnormal.
	4	When the ignition is turned ON, does the fuel pump run for about 3 seconds and then stop?		If not working properly, poor connection (grounding) of (disconnected) gray cable in body.
device	5	Does the device's SSID appear when the vehicle is turned on?		If not displayed, poor power connection or device failure.
	6	Check the device graph to see if the O2 sensor input status is correct*.		If the device does not work properly, it is either damaged inside the device or the program is faulty.
	7	Is the black-to-gray voltage 450 mv ( $\pm 1\%$ ) when the device's air-fuel ratio setting is set to "disable"?		If the device does not work properly, it is either damaged inside the device or the program is faulty.
	8	When the device map is switched, is the resistance between cables as follows? MAP2: 0Ω between brown and black MAP3: 0Ω between green and black		If the device does not work properly, it is either damaged inside the device or the program is faulty.

### TIPS

The operation of the device alone can be checked by connecting a 9v battery as shown in the following figure. (Items 5, 7, 8)



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## Appendix: O2 sensor specifications and measurement results

The ECU in the R1100S (R1150) uses a BOSCH Step change (narrow band) O2 sensor to adjust fuel.

Although ECU specifications are not disclosed, the output of this device to the ECU was determined based on the specifications of the BOSCH narrowband O2 sensor and the voltage measurements of the ECU.

The BOSCH O2 sensor documents referenced are as follows.

[https://www.boschaftermarket.com/xrm/media/images/country\\_specific/sg/services\\_and\\_support\\_6/downloads\\_18/lambda\\_sensors.pdf](https://www.boschaftermarket.com/xrm/media/images/country_specific/sg/services_and_support_6/downloads_18/lambda_sensors.pdf)

----- Quote: -----

*Step-change sensors detect the "stoichiometric mixture" ( $\lambda = 1$ ) and compare the residual oxygen content of the exhaust gas with the oxygen content of the ambient air. They detect the transition from rich to lean air/fuel ratio and vice versa. Depending on the oxygen content of the exhaust gas, they generate a voltage of approx. 20 to 900 mV.*

*Check signal profile - step-change sensor:*

- *Control sensor signal oscillates between approx. 0.1 and 0.9 V*
- *The larger the control-sensor voltage boost, the better the signal*
- *The lower the voltage boost of the diagnostic sensor, the better the condition of the catalytic converter*
- *Frequency between 0.3 and 3 Hz*
- *Voltage < 0.4 V → lean mixture*
- *Voltage > 0.5 V → rich mixture*

*Check control unit:*

- *Is the reference voltage 450 mV?*

*Check the power supply of the lambda sensor heater*

*Check the actual values of the lambda sensor heater using a diagnostic tester.*

*There must be a constant power supply of 10.5 to 13.5 V. Is the power supply OK?*

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## measurement results

The measurement results of the sensors, ECUs, etc. involved were as follows.

- ECU black-GND: around 0.59v
- ECU gray-GND: around 0.14v
- ECU black-gray: around 0.45v

\*This value is consistent with the BOSH reference voltage.

- O2 sensor when warm, black gray: around 0.14v
  - \*O2Heat a single sensor to about 1000°C by roasting it with a gas burner.
- GSS911 O2 sensor when cold: 0.45v
- GSS911 O2 sensor when warm: 0.14v
- LC-2 cold analog output: 0.45v
- LC-2 warm analog output: 0.14v

## Guess the ECU's fuel adjustment logic

- To determine the failure of the O2 sensor, a potential difference of 0.45v is measured in black and gray.
- The ECU uses the O2 sensor's  $\lambda=1$  (A/F 14.7) as threshold and three voltages as inputs: dark (below 0.4v), light (above 0.5v), and intermediate (0.4v-0.5v).
- By appropriately shifting the voltage input to the ECU, the A/F can be controlled.

## Relationship between voltage shift value and A/F

Using LC-2 (air-fuel ratio logger with broadband O2 sensor) on a stock 98 R1100S, we measured the relationship between the voltage shift of the narrowband O2 sensor and the air-fuel ratio

Shift Voltage	A/F
-0.30	15.3
-0.20	15.1
-0.10	14.9
0.00	14.7
0.10	14.5
0.20	14.3
0.30	14.0
0.37	13.7

However, these figures are approximabrownnd may vary depending on individual bodywork and customization of intake and exhaust systems, etc.

If the shift value exceeds -0.4v - 0.4v, the operating range of the O2 sensor becomes significantly narrower, resulting in a larger A/F ratio error.

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## Appendix: Development Resources/Development Environment

### Project Outline

[Home | BMW R1100S ECU tuning Project \(tmp-net.biz\)](https://tmp-net.biz/)

### Development Resources

<https://github.com/y23tanaka/Lambdgrayifter2.0/>

### Development environment

- Windows10 / VSCode / PlatformIO
- Arduino(C++) / HTML5 / Javascript
- Design Spark

### Cautions for DIY

- ESP32 must be installed with firmware and files on the chip itself. Need to purchase an ESP32 mountable/removable development board with USB adapter for installation.
- Before installation, it is necessary to calibrate the input (white) and output (yellow) of the O2 sensor of the device, because the input and output values of the ESP32 ADC vary from one device to another.

The relevant parts of the program are as follows

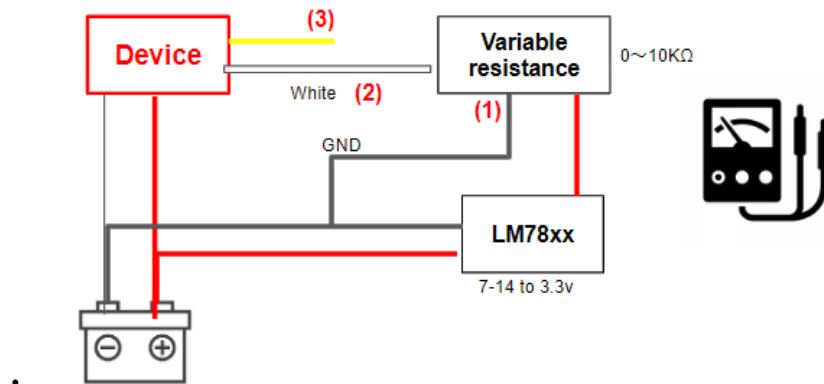
### ADC

```
in_volt1 = (in_volt1 * 5 + o2_value1 + 14 - (o2_value1 * 0.0155)) / 6;  
in_volt2 = (in_volt2 * 5 + o2_value2 + 14 - (o2_value2 * 0.0155)) / 6;
```

### DAC

```
int out_duty1 = round((in_volt1 + shift_value - 60) * 0.0815);  
int out_duty2 = round((in_volt2 + shift_value - 115) * 0.0830);
```

Create the following circuit and use a voltmeter to measure the voltage between (1) and (2) (input) and between (1) and (3) (output) to fair the error in the device's measurements.



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The data at the time of calibration is shown below for reference.

<https://github.com/y23tanaka/LambdaShifter2.0/blob/master/test/calibration.xlsx>

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## Appendix: Frequently Asked Questions

- **What happens if the device is broken?**

If the device is completely broken, from the ECU's point of view, the ECU's map will be in emergency mode because the O2 sensor signal will be lost (behavior varies depending on car model). In this case, it will not be possible to connect via WiFi to the device. There is no track record of incomplete breakage, such as improper sensor output values.

- **Why does the sensor input value not fall below 120 mV?**

This is a device specification. It does not affect the operation.

- **Why does the output value not exceed 900-950mV/not fall below 100-150mV?**

This is for ECU protection. It does not affect the operation.

- **Can it be manipulated by someone else who has the same device?**

Very difficult, because SSID and password are different for each device.

- **Browser communication is not encrypted.**

Specifications. As long as the radio is encrypted, it is very difficult to intercept.

- **Weak wireless signal**

Adjust the installation position so that there is no metal between the device and the smartphone or other device that will receive the radio signal.

- **What happens if the logging time exceeds 120 minutes?**

Web access to the device may become unavailable. The voltage adjustment function operates normally. Reboot the device by turning off the ignition once, etc. If the device is rebooted, the log file will be lost.

- **Lost information to access the device.**

Please contact us and we will need your SSID (serial number) or the information of the purchaser. The SSID will be "LS20-AP XXXX" which can be confirmed from a smartphone or other device when the device is turned on.

- **Are there any fire or other hazards?**

The possibility is very low because we are dealing with a weak signal for the sensor. The design of the device is such that when the power supply is connected in reverse, the fuse will blow and the protection circuit inside the device will break if an overvoltage is applied. If an abnormal voltage is applied to the sensor, the internal IC may be damaged, resulting

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in a temperature of about 60°C. To protect against vibration, the internal circuit board is filled with a heat-resistant adhesive that can withstand temperatures of 100°C or higher.

- **I want to change the design of the graph or add a function.**

Depends on the contents. In principle, we will charge a fee for this service.

- **I would like the menu text to be larger/smaller.**

This is difficult because the site is intended to be accessed from multiple environments, such as mobile phones and PCs. Adjustments for specific environments can be made for a fee.

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## **Appendix: Contact Information**

Inquiries about hardware and software design

<https://github.com/y23tanaka/Lambdgrayifter2.0/>

Inquiries about usage and acquisition channels

<https://www.facebook.com/yosuke.tanaka.169>

[service@tmp-net.biz](mailto:service@tmp-net.biz)

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## **Appendix: License Information**

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