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USER MANUAL

EMU Black

Document version: 1.3
Firmware version: 2.169 or later
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ECUMASTER

Contents

1. Device description

The **EMU Black** is a standalone engine control unit designed for internal combustion engines with 1 to 12 cylinders. It supports a wide range of engine types and control strategies, including knock control, drive-by-wire (DBW) throttle systems and variable valve timing (VVT). The hardware is designed for demanding environments, with an IP60-rated enclosure, conformal-coated PCB, and a -40°C to +105°C operating temperature range.

> **Warning:**
> This product is not intended for use on public roads.

Key Features

- Integrated wideband lambda controller (Bosch LSU 4.2 / 4.9 support)
- Built-in 4-bar MAP sensor
- Two direct EGT (exhaust gas temperature) probe inputs
- Flex Fuel support
- Direct control of up to 6 passive or 12 smart ignition coils
- Drive-by-wire support with safety layers and plausibility checks
- Engine compatibility – supports 1-12 cylinder engines, including DBW and VVT systems
- Configurable CAN communication
- Support for user-defined custom functions
- IP60-rated enclosure and conformal-coated PCB
- Automotive-grade components (AEC-Q100 Grade 2)
- Suitable for engines in race cars, motorcycles, marine, and stationary installations

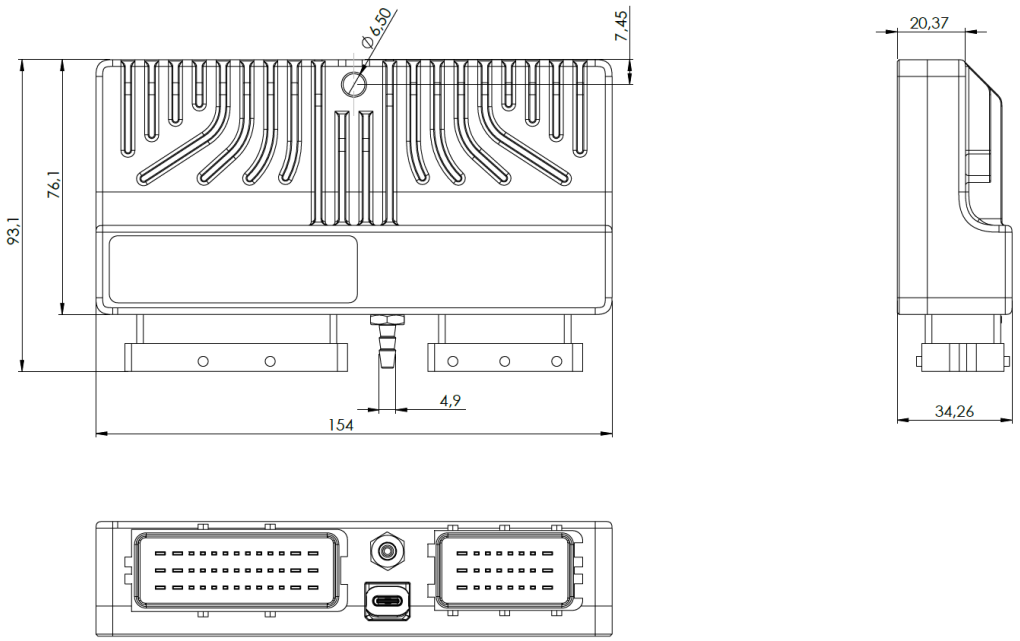
2. Specification

Specification	
Temperature range	AECQ100 GRADE2 (-40 to +105˚C)
Operating voltage	6-22V, immunity to transients according to ISO 7637
Minimal current consumption	0.25 A
Power supply overcurrent protection	5 A fuse for ignition switch supply 15 A fuse for 12 V battery supply
Enclosure rating	IP 60, custom CNC machined aluminium
Weight	390 g
Dimensions	150 x 72 x 31 mm
Connectors	Gray connector: 24 Sicma FCI 211PC249S8033, Black connector: Custom-made for Ecumaster[1]
Terminals	45 x 211CC2S2160P, 18 x 211CC3S2120
PC communication	USB (with PC client software)
Communication	CAN bus 2.0B, Serial
CAN standard	CAN 2.0B
CAN bus bitrate	1 Mbps (default), 500 kbps, 250 kbps, 125 kbps
CAN termination	Software-selectable
Number of injector outputs	6
Number of Ignition outputs	6 passive or 12 active ignition coils
Aux outputs	6 protected outputs 5A, low side
Other outputs	Full bridge up to 7A, can be used as separate outputs or 2 H-Bridges
Analog inputs	9 inputs, resolution 10Bits, 0-5V (protected)
Switch inputs	3 inputs, switched to ground
EGT inputs	2 for K-Type thermocouple
Knock sensor inputs	2
Oxygen sensor support	LSU 4.2 or 4.9 (built in controller), Narrow band, external WBO controllers
Drive-by-wire (DBW) support	1, auto-calibration

Variable Valve Timing (VVT)	Up to 2
RPM limit	Tested for up to 15,000 RPM
Data logging	Real time logging to PC, logging to the SD card with external logger - EDL-1 https://www.ecumaster.com/products/data-logger-dl-1/

[1]You can order additional connectors from your Ecumaster dealer.

All dimensions in mm



3. Pinout

Pinout for EMU Black: https://www.ecumaster.com/wp/wp-content/uploads/2020/05/EMU_Black_pinout.pdf

4. Installation

Mounting the EMU Black

1. Mounting Location:

- It is recommended to mount the EMU Black in a safe location, preferably inside the cabin, rather than in the engine compartment.
- Although the EMU Black has an IP60 rating for dust resistance, avoid areas where the device could be exposed to water, mud, or excessive moisture.

- Keep the unit away from heat sources such as exhaust system or the turbocharger.
- Avoid areas where high temperatures or moving mechanical components could affect the EMU Black from behind.
- Ensure the location minimizes the risk of accidental contact by the driver, co-driver, or passengers.

2. Device Orientation:

- The EMU Black can be mounted in any orientation.
- For optimal heat convection, it is recommended to mount the radiators facing upwards or in an orientation between 0 to 90 degrees.
- Avoid mounting the device upside down to ensure proper heat dissipation.

3. Stable Mounting:

- Use the factory mounting point in the housing (1 x M6 bolt) to securely mount the device.
- Avoid mounting the EMU Black directly to structural parts of the vehicle, such as the chassis, firewall, or other rigid components. These parts can transmit strong vibrations or mechanical stress, which may negatively affect the device over time.
- While vibration isolators are not mandatory, if the device is exposed to significant shocks or vibrations, consider using rubber-metal silent blocks for added protection.

4. Additional Guidelines:

- Ensure plugs are easily accessible for servicing, diagnostics, or emergency disconnection.
- Leave sufficient "working clearance" around the plug side of the harness to allow for easy unplugging.
- Allow at least 20mm of free space around the EMU Black case to facilitate air circulation and effective heat dissipation.

Wiring Guidelines

- Keep wiring lengths as short as possible to reduce signal interference and voltage drops.
- Use shielded cables for sensitive sensor inputs, particularly for crankshaft and camshaft position sensors.
- Route power and ground cables separately from signal wires to minimize electrical noise.
- Ensure all grounds are connected properly to a common grounding point to prevent ground loops.
- CAN bus wiring should be twisted pair and properly terminated with 120-ohm resistors at both ends of the network.

- The wire gauge (AWG) should be selected according to the current load expected to flow through the wires. Ensure that the wire diameter is suitable for the current to prevent overheating and voltage drop.

Minimal Configuration

To establish basic communication and functionality for bench testing, the following connections must be made:

- **Power Supply**: Connect to: **B13**.
- **Ground**: Connect to one of the available ground pins: **B27**, **G17**, **G24**.
- **+12V Switched:** Connect to **G18**.
- **PC Communication**: Handled via the USB-C port.

> **Note:**
> This minimal setup is intended for bench testing only.
> For full installation in a vehicle, all power supply and ground pins must be connected.

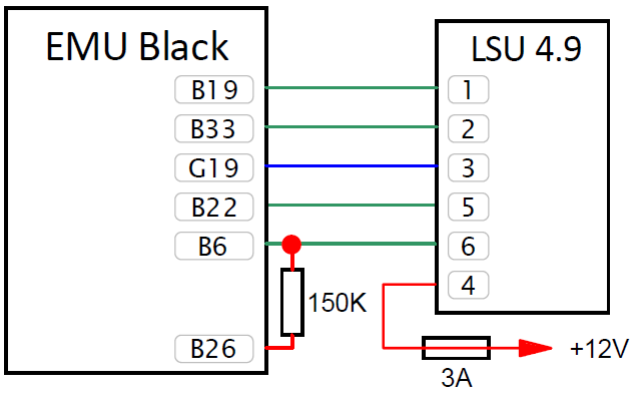
Power Supply

- The EMU Black requires a stable power supply within the specified voltage range (6-22V).
- Use appropriately rated fuses and relays to protect the power circuit.
- Ensure a solid ground connection to the chassis or engine block for reliable operation.

Sensor and Actuator Connections

- Verify that all sensors are correctly connected according to the engine configuration.
- Drive-by-wire (DBW) systems require correct calibration before use.
- Outputs for injectors, ignition coils, and solenoids should match the electrical characteristics of the connected components.

- When installing an LSU 4.9 wideband oxygen sensor on an EMU Black device with a PCB revision lower than “O”, a **150 KOhm resistor** must be installed between the WBO Vs signal and +5V reference.
  To determine whether this requirement applies to your device, check the main board revision in the EMU Black Client software: ***Help / About***
  Devices with main board revision “O” do not require this resistor, as the circuit is already integrated on the PCB.



CAN Bus Communication

The EMU Black is equipped with a single CAN 2.0B bus, which can be used for communication with external devices such as dashboards, power management units, and expansion modules. When configuring the CAN bus:

- Use only twisted-pair wiring for CAN H and CAN L signals.
- Ensure that both ends of the bus are terminated with 120-ohm resistors.
- The CAN bus bitrate should be configured to match connected devices.
- Avoid branching connections; use a linear bus topology where possible.

The following logging channels related to CAN communication can be monitored in the EMU Black software:

- ***CANBUS State*** - the status of the CAN bus
- ***CANBUS Load*** - the processing load of CAN data being sent from the device
- ***CANBUS Overload*** - the requested amount of data to be sent on the CAN bus exceeds the device's buffer size. Some frames may not have been sent
- ***CANBUS Rx Buffer Ful*** - the requested amount of data to be received on the CAN bus exceeds the device's buffer size. Some frames may not have been received

Meaning of *CANBUS States*:

- *BUS OK* - no communication errors
- *BUS ERROR* - CAN bus error. Possible causes may include incorrect bus speed selection, lack of termination, error in connecting CANL and CANH, or ID collision

PC Communication

The EMU Black communicates with a PC via a direct USB-C connection.

To configure the ECU, install the EMU Black Client software on your computer before the first connection.

The latest official release is available from the product page https://www.ecumaster.com/products/emu-black/, while test versions are available on a https://www.ecumaster.com/testVersions.html.

Wiring Diagrams

For a connection example and wiring diagram, refer to the resource below: https://www.ecumaster.com/files/EMU_BLACK/Wiring_Diagram_Example_4_cylinders_EMU_BLACK.pdf

5. EMU Black Software

The configuration of the EMU Black is done through the EMU Black Client. A detailed description of the software is available at: https://ecumaster.com/files/EMU_BLACK_V3/EMU_BLACK_V3_Software_Guide.pdf.

The currently available guide refers to software version V3. Some of the information may also apply to V2. A complete V2 Software Guide is currently being prepared.

6. CAN Stream

The default CAN bus bitrate of the device is **1 Mbps**. The format used is **little-endian**.

Byte	Channel	Data Type	Range	Multiplier/ Divider	Factor	Offset	Unit
EMU stream base ID+0 (default: 0x600)							
0..1	RPM	16-bit U	0 – 16000	1/1	1	0	RPM
2	TPS	8-bit U	0 – 100	1/2	0.5	0	%
3	IAT	8-bit S	-40 – 127	1/1	1	0	C
4..5	MAP	16-bit U	0 – 600	1/1	1	0	kPa
6..7	Injector PW	16-bit U	0 – 50	1/62	0.016129	0	ms
EMU stream base ID+1 (default: 0x601)							
0..1	AIN #1	16-bit U	0 – 5	5/1024	0.0048828125	0	V
2..3	AIN #2	16-bit U	0 – 5	5/1024	0.0048828125	0	V
4..5	AIN #3	16-bit U	0 – 5	5/1024	0.0048828125	0	V
6..7	AIN #4	16-bit U	0 – 5	5/1024	0.0048828125	0	V
EMU stream base ID+2 (default: 0x602)							
0..1	VSPD	16-bit U	0 – 400	1/1	1	0	km/h
2	BARO	8-bit U	50 – 130	1/1	1	0	kPa
3	Oil Temperature	8-bit U	0 – 160	1/1	1	0	C
4	Oil Pressure	8-bit U	0 – 12	1/16	0.0625	0	bar
5	Fuel Pressure	8-bit U	0 – 12	1/16	0.0625	0	bar
6..7	CLT	16-bit S	-40 – 250	1/1	1	0	C
EMU stream base ID+3 (default: 0x603)							
0	Ignition Angle	8-bit S	-60 – 60	1/2	0.5	0	deg
1	Dwell Time	8-bit U	0 – 10	1/20	0.05	0	ms
2	Lambda	8-bit U	0 – 2	1/128	0.0078125	0	lambda
3	Lambda Correction	8-bit U	75 – 125	1/2	0.5	0	%
4..5	EGT1	16-bit U	0 – 1100	1/1	1	0	C
6..7	EGT2	16-bit U	0 – 1100	1/1	1	0	C
EMU stream base ID+4 (default: 0x604)							
0	Gear	8-bit U	0 – 7	1/1	1	0	
1	ECU Temperature	8-bit S	-40 – 120	1/1	1	0	C
2..3	Battery Voltage	16-bit U	0-20	27/1000	0.027	0	V

Byte	Channel	Data Type	Range	Multiplier/ Divider	Factor	Offset	Unit
4..5	Error Flag[1]	16-bit	bitfield	1/1	1	0	
6	FLAGS 1[2]	8-bit	bitfield	1/1	1	0	
7	Ethanol Content	8-bit U	0-100	1/1	1	0	%
EMU stream base ID+5 (default: 0x605)							
0	DBW Position	8-bit U	0 – 100	1/2	0.5	0	%
1	DBW Target	8-bit U	0 – 100	1/2	0.5	0	%
2..3	TC DRPM RAW	16-bit S	0 – 1000	1/1	1	0	
4..5	TC DRPM	16-bit U	0 – 400	1/1	1	0	
6	TC Torque Reduction	8-bit U	0 – 100	1/1	1	0	%
7	PIT Limiter Torque Reduction	8-bit U	0 – 100	1/1	1	0	%
EMU stream base ID+6 (default: 0x606)							
0..1	AIN #5	16-bit U	0 – 5	5/1024	0.0048828125	0	V
2..3	AIN #6	16-bit U	0 – 5	5/1024	0.0048828125	0	V
4	OUTFLAGS1[3]	8-bit	bitfield	1/1	1	0	
5	OUTFLAGS2[4]	8-bit	bitfield	1/1	1	0	
6	OUTFLAGS3[5]	8-bit	bitfield	1/1	1	0	
7	OUTFLAGS4[6]	8-bit	bitfield	1/1	1	0	
EMU stream base ID+7 (default: 0x607)							
0..1	Boost Target	16-bit U	0 – 600	1/1	1	0	kPa
2	PWM#1 DC	8-bit U	0 – 100	1/1	1	0	%
3	DSG Mode[7]	4-bit U	enumeration	1/1	1	0	
4	Lambda Target	8-bit U	0 – 1	1/100	0.01	0	lambda
5	PWM#2 DC	8-bit U	0 – 100	1/1	1	0	%
6..7	Fuel Used	16-bit U	0 – 255	1/100	0.01	0	liter

[1]Bits of **Error Flag** bitfield

Bit index	Error name	Description
0	ERR_CLT	Coolant temperature sensor failed
1	ERR_IAT	IAT sensor failed
2	ERR_MAP	MAP sensor failed
3	ERR_WBO	Wide band oxygen sensor failed
4	ERR_EGT1	EGT sensor #1 failed
5	ERR_EGT2	EGT sensor #2 failed
6	ERR_ALARM	EGT too high
7	KNOCKING	Knock detected
8	FFSENSOR	Flex Fuel sensor failed
9	ERR_DBW	Drive by wire failure
10	ERR_FPR	Fuel pressure relative error

[2]Bits of **FLAGS1** bitfield

Bit index	Name	Description
0	GEARCUT	Gearcut active
1	ALS	ALS active
2	LC	Launch control active
3	IDLE	Is in idle state
4	TABLE SET	0 - using table set #1, 1 - using table set #2
5	TC INTERVENTION	1 - traction control intervention
6	PIT LIMITER	Pit limiter active

[3]Bits of **OUTFLAGS1** bitfield

Bit index	Name	Description
0	PO1	Parametric output #1 state
1	PO2	Parametric output #2 state
2	PO3	Parametric output #3 state
3	PO4	Parametric output #4 state
4	PO5	Parametric output #5 state

Bit index	Name	Description
5	VPO1	Virtual output #1 state
6	VPO2	Virtual output #2 state
7	VPO3	Virtual output #3 state

[4]Bits of **OUTFLAGS2** bitfield

Bit index	Name	Description
0	CANSW1	CAN switch #1 state
1	CANSW2	CAN switch #2 state
2	CANSW3	CAN switch #3 state
3	CANSW4	CAN switch #4 state
4	CANSW5	CAN switch #5 state
5	CANSW6	CAN switch #6 state
6	CANSW7	CAN switch #7 state
7	CANSW8	CAN switch #8 state

[5]Bits of **OUTFLAGS3** bitfield

Bit index	Name	Description
0	SW1	Switch #1 state
1	SW2	Switch #2 state
2	SW3	Switch #3 state
3	MUXSW1	MUX switch #1 state
4	MUXSW2	MUX switch #2 state
5	MUXSW3	MUX switch #3 state
6	LC MAP SET	Current set of launch control parameters
7	ALS MAP SET	Current set of ALS parameters

[6]Bits of **OUTFLAGS4** bitfield

Bit index	Name	Description
0	FPS	Fuel pump state
1	CF	Coolant fan state

Bit index	Name	Description
2	ACCLUTCH	AC clutch state
3	ACFAN	AC fan state
4	NITROUS	Nitrous active
5	STARTER_REQ	Starter motor request (from start / stop strategy)
6	BOOST MAP SET	Current set of boost parameters

[7]Values for channel: **DSG Mode**

Value	Description
2	P
3	R
4	N
5	D
6	S
7	M
15	fault

7. Document history

Version	Date	Changes
1.0	2025.07.03	Initial release
1.1	2025.08.13	Updated connector specification
1.2	2025.11.17	Added information about the EMU Black software guide
1.3	2026.04.16	Added LSU 4.9 sensor compatibility information for PCB revisions below “O”