MP3 Hybrid

PIAGGIO

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PIAGGIO HYBRID TECHNOLOGY

HY TECH

WHAT IS A HYBRID?

A hybrid is more than simply a vehicle with two powerplants

Hybrid is a drive system integrating the advantages of two different power sources in a single solution.

MP3 hybrid: two scooters in one for safe, easy and fun total mobility.

WHY MP3 HYBRID?

TRAFFIC The practicality and comfort of a scooter

SAFETY Unrivalled in its class, with three wheels and triple disc brakes

ENVIRONMENT The advantages of hybrid technology

PIAGGIO MP3 HYBRID: FCS

1. *The most advanced scooter on the market*	**The world's first and only scooter with parallel hybrid technology, the world's first plug-in hybrid vehicle and the first hybrid with lithium batteries**
2. *The lowest fuel consumption in its segment*	**Up to 60 Km/litre * (145 mi/1.0 US gal)**
3. *The lowest emissions in its segment*	**Just 40g/Km CO2* (1.4 oz/0.6 mi)**
4. *Access to restricted traffic zones*	**20 Km range in pure electric mode (12.4 mi)**
5. *Up to 85% more power*	**Acceleration and pickup comparable to larger engined MP3**
6. *Easy to ride*	**Reverse**
7. *Rechargeable directly from the household mains (Plug-in):*	**Full charge in just 3 hours with a standard power cable**

* With 65% use in hybrid mode and 35% in electric mode

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1.1 USING THE SYSTEM

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1.1 USING THE SYSTEM

The 4 modes are selectable with the TECH" button on the right hand handlebar switchgear set

Operating modes displayed on instrument panel LCD

State of battery charge

HYBRID

a) Hybrid Power → Traction battery energy is used (improved performance and economy and reduced consumption and emissions)

b) Hybrid Charge → If charging from the mains is not possible, the petrol engine is used to charge the battery.

ELECTRIC

c) Electric → Electric power only is used →ZEV – Zero Emissions Vehicle.A reverse mode is also available to facilitate parking.

d) Reverse

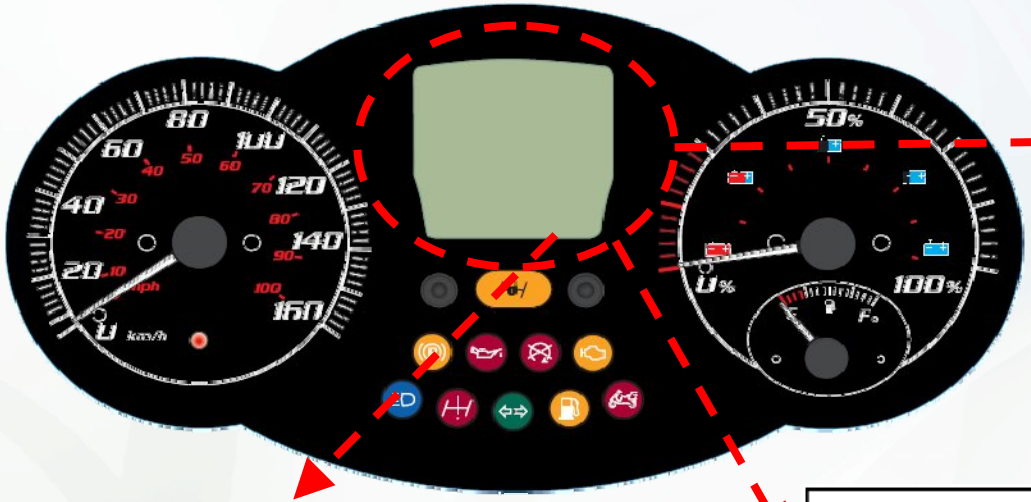
At KEY-ON, the last mode selected is displayed:

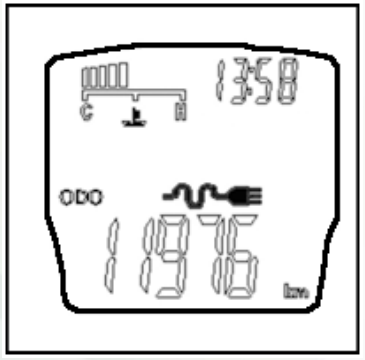
- if the vehicle was switched off in one of the two hybrid modes, at the subsequent key-on, the same hybrid mode is preselected and indicated on the display panel, with the relative message indicated constantly;

- if the vehicle was switched off in electric mode, at the subsequent key-on, the same electric mode is preselected and indicated on the display panel with the relative flashing message.

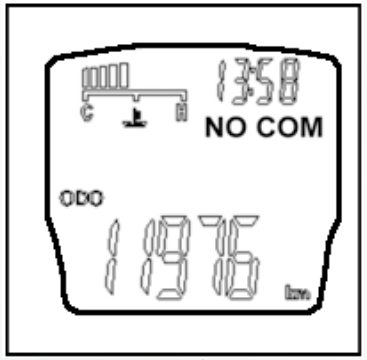
The required mode, whether it be the mode active before the last key-off or a new selection, must be confirmed by pressing and holding the HY TECH button for at least 1 second.

1. In the Hybrid modes, confirming with the Hy Tech button automatically starts the petrol engine if the throttle grip is released.
2. In the Hybrid modes, the petrol engine may also be started by pressing the conventional starter button.
3. In the Electric modes, confirming with the Hy Tech button readies the electric motor for immediate power delivery when requested.

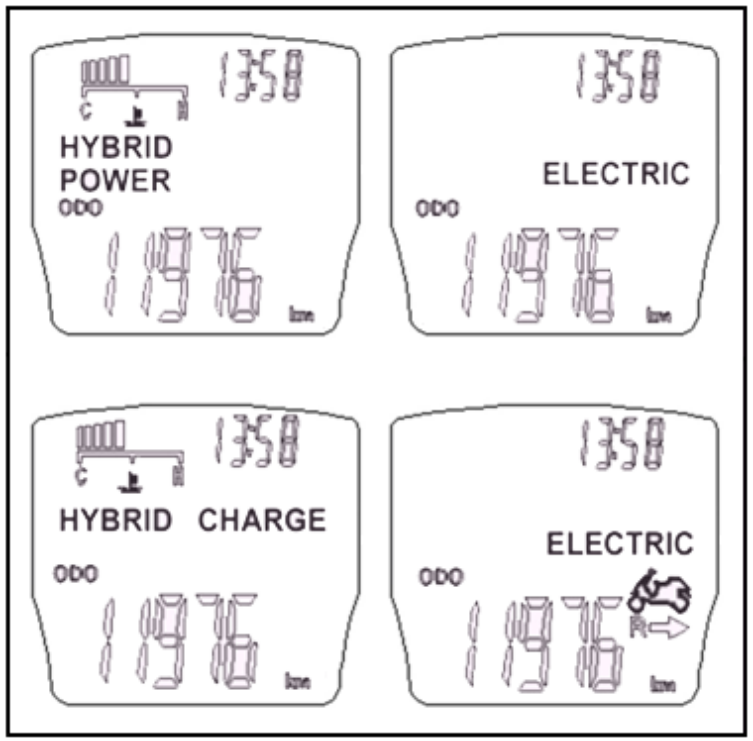




Indicates that the mains charging plug has been removed from its housing. The vehicle cannot be started in this state as it is in mains charging mode!

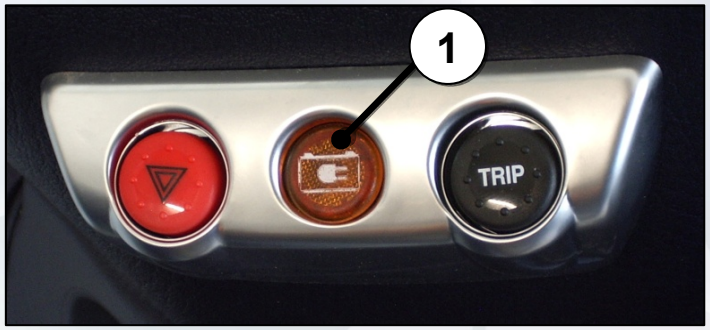


Indicates no communication between the traction battery ECU and the Kuadro ECU.



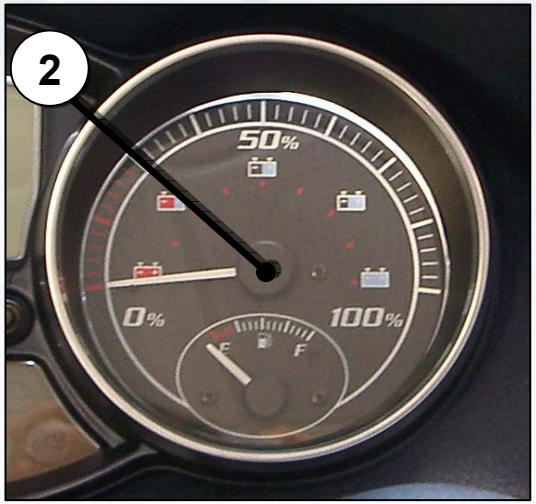
Indicate the different operating modes

When the traction battery charge level approaches 0%, the charging indicator light (**1**), located at the centre of the handlebar cover, starts **flashing.** This means that the vehicle **must** be **recharged from the mains** or, **should this not be possible, that HYBRID CHARGE** mode must be selected.



To charge from the mains, the ignition key must be switched OFF.

When charging from the mains, the Kuadro ECU cooling fan is activated and the charging indicator light is lit; to view the charge level while charging is in progress, turn the ignition key ON and read the level from the relative indicator (**2**).



To charge from the mains, lift the saddle and remove the charging plug(**3**), twisting slightly anticlockwise.

This vehicle is equipped with the plug type required by currently applicable legislation for charging from public charging stations.

To charge from the household mains (220/110V), use the adaptor supplied.

A full charging cycle from the mains takes approximately **3 hours**. The optimum temperature range for battery use/charging is **5° - 60°C**. The battery may not charge correctly at temperatures below 0°C.

The indicator light (**1**) extinguishes when the charging process is complete. Remove the plug from the mains socket and return to the relative housing under the saddle, turning the plug clockwise to secure.

1.2 WORKING PRINCIPLE

"Hybrid" is a drive system integrating the advantages of two different powerplants in a single solution:

1. **Petrol engine**
2. **Electric motor**

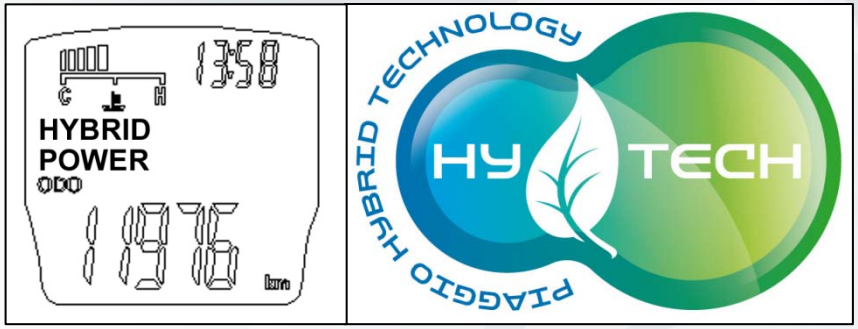
The two different power sources are used synergically and simultaneously **(= in parallel)** in an integrated system with management strategies and logic optimised to use each powerplant in the most efficient conditions.

Feature	Hybrid charge	Electric	Hybrid power
Range			
Emissions			
Power at high engine speeds			
Power at low engine speeds			

HYBRID POWER MODE

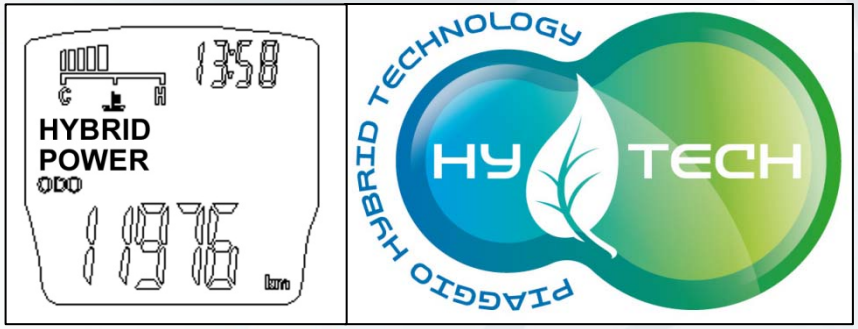
- At **constant speed:** the electric motor drives the rear wheel in parallel with the petrol engine, adding up to **15 Nm of torque (rated)** to the driven pulley at low engine speeds.Up to 7,000 rpm (approx. 60 Km/h), the electric motor adds up to **2.5 kW** to the **power** produced by the petrol engine. Above 8,000 rpm, the electric motor no longer contributes to power delivery.

- Under **acceleration**: the electric motor drives the rear wheel in parallel with the petrol engine, boosting torque by up **85% (125 cc)** or **65% (300** cc) compared with the value produced by the petrol engine alone. The proportion of torque produced by the electric motor is particularly high at low speeds, resulting in lower emissions and fuel consumption.



- Under **deceleration:** (braking or closed throttle), the electric motor recovers kinetic energy and uses it to charge the traction battery; when it functions as a generator, the electric motor produces a negative torque contribution equating to a braking power of 1.5 kW.

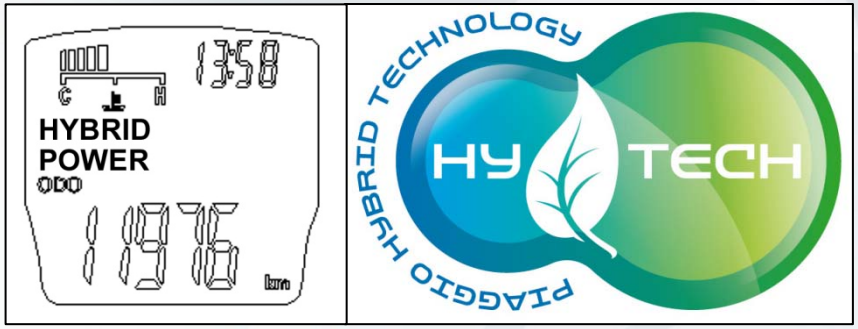
- Under braking or when riding downhill, the conventional mechanical brake system (calliper + disc) is not used alone to slow the vehicle, as the electric motor also steps in to produce a braking effect. The control system electronics adapt the operating parameters of the electric motor to recover kinetic or potential energy which would otherwise have been dispersed as heat, partially converting it into electric energy (regenerative braking or KERS).



- At speeds above 20 Km/h (12.5 mph), only Hybrid Power and Hybrid Charge modes are selectable from the instrument panel; under 20 Km/h (12.5 mph) and with the throttle grip released, electric mode may also be displayed and selected, to turn off the petrol engine and switch automatically from Hybrid →mode to Electric mode (meaning that the vehicle can be ridden in areas restricted to electric vehicles only).

- **Battery range in this mode (Electric) is approximately 20 Km (12.42 mi), which is sufficient for the average daily usage for which the vehicle is intended.**

- 30,000 Km (18642 mi) in 5 years; 6,000 Km (3728 mi) / year; 30 Km (18.65 mi) / day over 200 days of usage

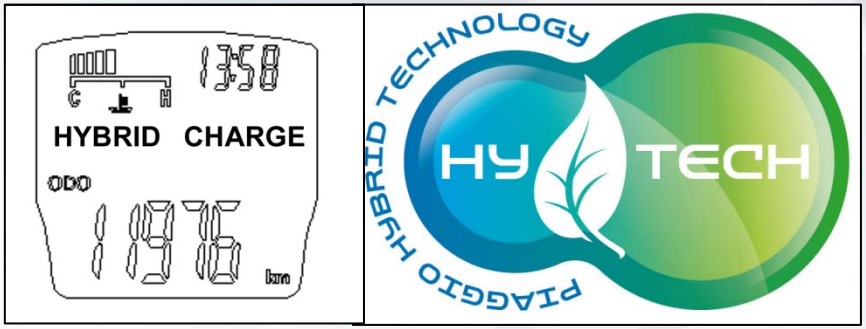


HYBRID CHARGE MODE

- In addition to providing torque for traction, the petrol engine also charges the battery when travelling at constant speed. The electric motor functions as a generator, producing a negative torque contribution. The electric motor only contributes to powering the vehicle at speeds up to 30 Km/h (18.6 mph). Under deceleration and braking, kinetic energy is recovered in the same way as in Hybrid Power mode.

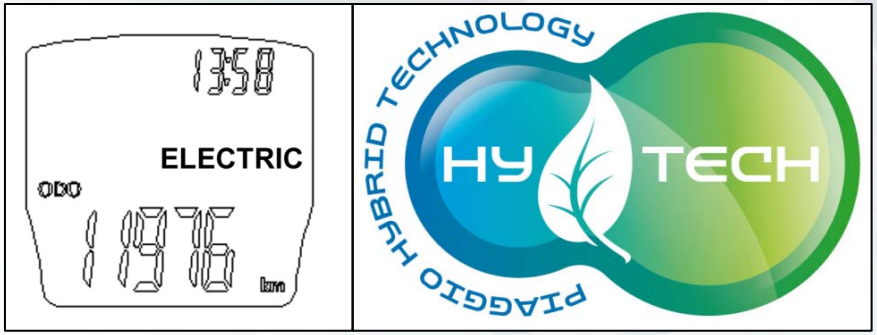
- T he target of the electronic control unit is to achieve and maintain a state of battery charge of **90% (achievable in approx. 2 hours)**.

- In similar operating conditions, the torque contribution produced by the electric motor under acceleration is less than in Hybrid Power mode.

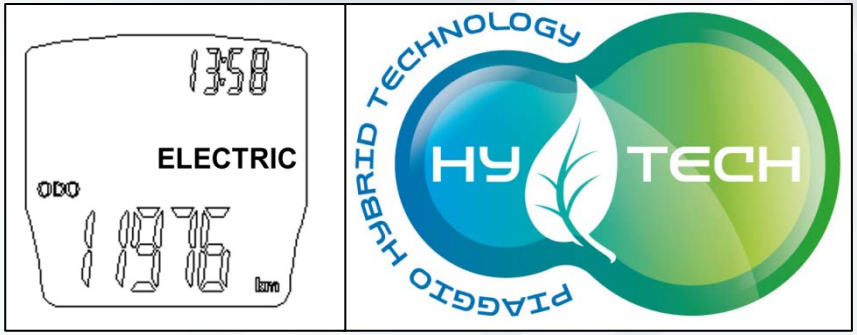


ELECTRIC MODE

- The electric motor drives the rear wheel, enabling **top speed** of **30 Km/h (18.6 mph)** and **a range** of approximately **20 Km (12.42 mi)**.
- Power in electric mode comes from the energy stored in the traction battery. As a result, maximum range is only possible with a fully charged battery.
- At a state of charge (SOC) **under 20%**, the control system electronics no longer permit electric drive.
- In electric mode, maximum (rated) torque is 15 Nm and maximum power is **2.5 kW**.

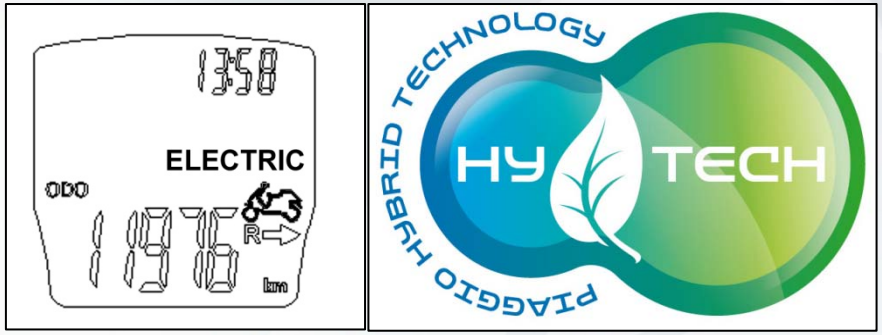


- In Electric mode, the MP3 may only be ridden with the parallelogram unlocked; the hold system control electronics command the automatic release of the parallelogram lock once a given throttle control aperture is exceeded and according to the normal hold system logic.
- Under braking, kinetic energy is recovered by the electric motor functioning as a generator and producing negative torque.
- From Electric mode, Hybrid Power or Hybrid Charge modes may be selected and confirmed from the instrument panel to switch from electric to hybrid mode when leaving an area restricted to electric vehicles only.



ELECTRIC REVERSE MODE

- Reverse mode is only selectable if the vehicle is stationary. When in reverse mode, the control electronics sound the warning buzzer when a certain percentage throttle grip aperture is exceeded.
- The electric motor functions as a normal motor, but produces negative torque, driving the vehicle in reverse.
- In Reverse mode, the MP3 may be ridden with the parallelogram either locked or unlocked; with the parallelogram locked, speed is limited to **3 Km/h (1.8 mph)** for rider safety, and **there is NO torque limiting**. This electric mode is useful for parking.



1.3 SYSTEM LOGIC

➢ ***System Architecture***

The 4 node star configuration CAN network interfaces the 4 ECUs on board of the vehicle:

1. **KUADRO** - **VMS** Vehicle Management System:

   Master ECU

2. **KUBO** - Ride by Wire petrol engine management:

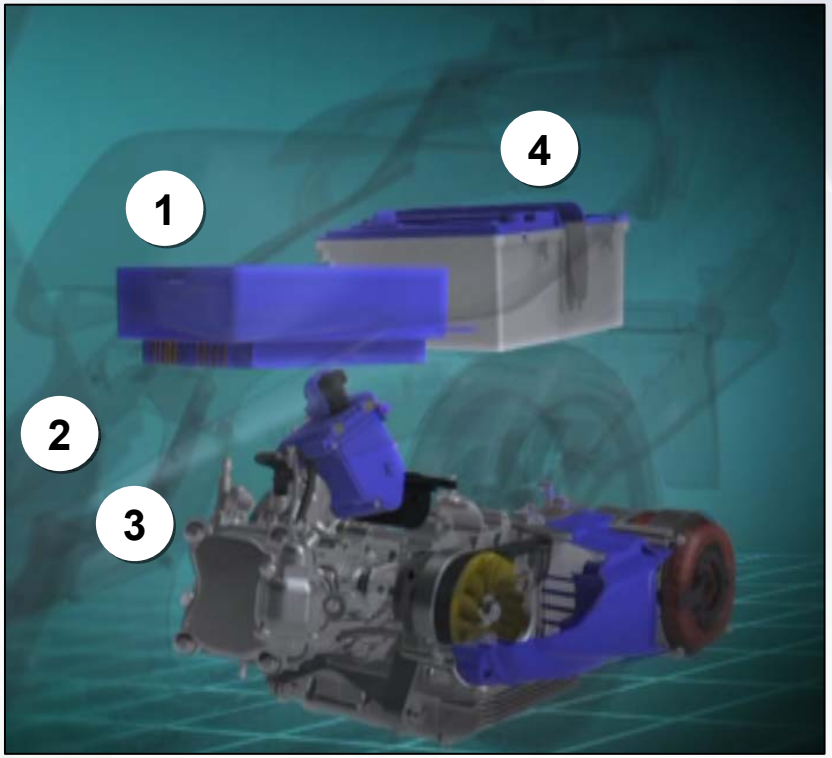
   Slave ECU

3. **CECA -** Hold system management:

   Slave ECU

4. **BMS** - Battery Management System – lithium ion battery management and control:

   Slave ECU



➢ *Logic for switching from hybrid modes to pure electric modes*

In “Electric” mode, the system is capable of responding to the torque request from the rider at point 5 in the following list.

1. Pure electric mode selected and confirmed via the Hy-Tech button and input received by **Kuadro** (VMS).

2. If the vehicle speed, measured by the electric motor position/speed sensor, is below 20 Km/h (12.42 mph) (throttle grip position is ignored), the **Kubo** (ECU) generates the **OK** signal for switching between hybrid and electric modes and sends the signal over the CAN line (petrol engine in idle control state ⇒petrol engine speed below clutch engagement point). The **Kuadro** transmits the “pure electric” operating mode signal over the CAN line, requesting zero torque and disabled petrol engine start from the system.

3. The petrol engine stops.

4. Petrol engine off state confirmed.

5. The system can now respond to torque requests from the rider using the electric motor only.

RECOVERY MODE MEASURES

In the event of malfunction of one or more of the vehicle management system devices, the Kuadro control unit informs the Kubo, control unit via the CAN line, **requesting activation of the engine fault warning light**.

Depending on the type of fault or recovery mode implemented, the warning light may be lit constantly or flashing, according to the following criteria.

CONSTANT ⇒Minor Fault **FLASHING ⇒Severe Fault**

There are different types of recovery mode, which are implemented in relation to the fault identified and in accordance with the logic of the control unit. Three examples are given as follows:

1. Electric motor torque limitation ⇒Constant
2. Vehicle speed limited to 50 Km/h (31 mph) ⇒Flashing
3. Soft Stop (the electric motor no longer delivers torque to the driven pulley shaft and the Kuadro control unit requests NO GAS recovery mode from the Kubo control unit, which entails a progressive reduction in torque until idle state is reached).

1.4 SYSTEM COMPONENTS

Electric motor

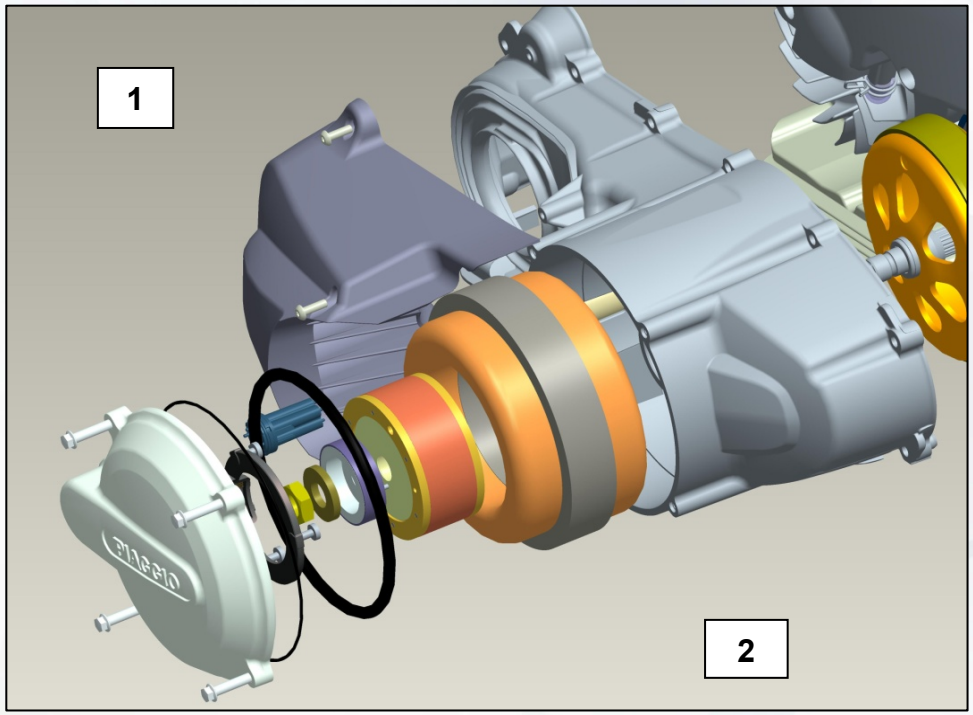
Brushless, alternating current motor consisting of:

1. Permanent magnet rotor;

2. Stator;

Position and speed sensor, consisting of: - Rotor;

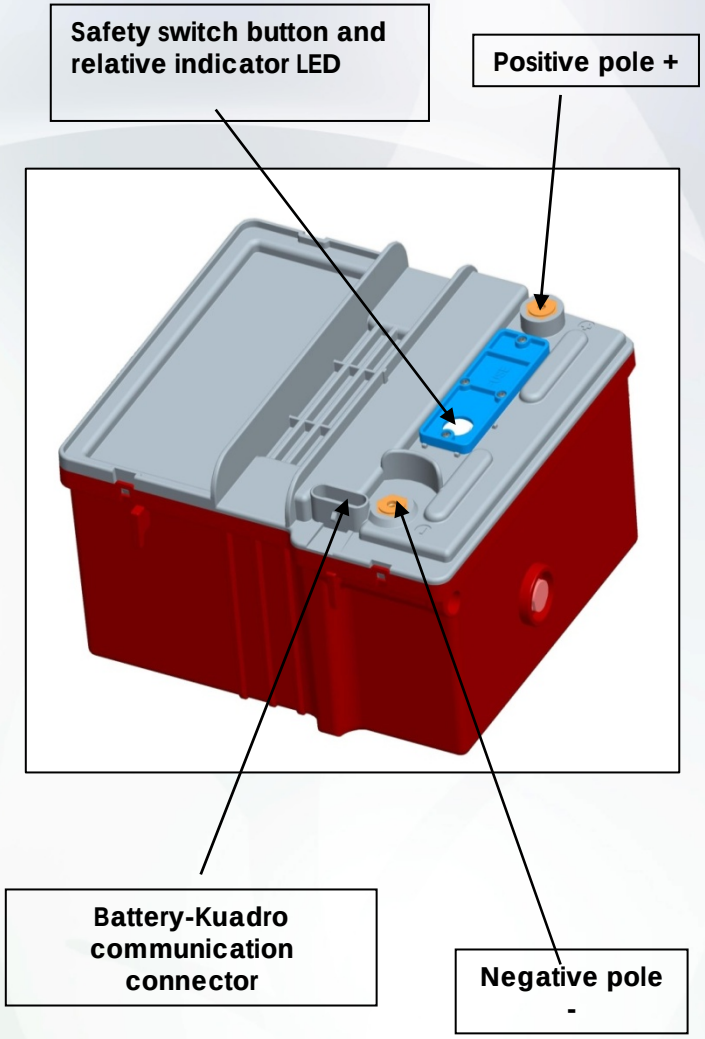
- Fixed part;



125/300 cc
Power output when operating as motor: 2.6 kW. Max. torque: 15Nm. Max. power output when operating as generator: 1.5 kW. Power supply voltage: 400 Volt AC.

Lithium ion battery

Rated voltage	37 V
Rated capacity	31 Ah
Rated energy storage	1.2 kWh
Rated discharge current	60 A
Peak discharge current	100 A for 30 s
Rated charge current	30 A
Peak charge current	80 A for 30 s
Lifespan	At least 1500 cycles, after which > 80% of rated capacity is still usable (estimated 5 years' use)
Self discharge	< 3% per month at 25 °C
Discharge temperature range	-20 to 75 °C
Charge temperature range	-20 to 75 °C
Weight	12 Kg (26.5 lb)
Maximum impedance, AC	10 mΩ



The helmet compartment must be removed to access to the batteries.

The BMS acts as insulation between the 12 V ground (services) and the 37 V ground (traction)

To arm the traction battery (37V), press and hold the button for approximately 1 second. This procedure must be performed with the ignition key ON to prevent the battery from being used before it is manually activated.

The switch has two LEDs: **the red LED** flashes when the battery is disarmed, the **green LED** flashes when the battery is armed.

At key ON, the Kuadro (EMD) generates a 12V start-up signal and sends it to the BMS. Before sending this signal (a few ms after key on), the Kuadro (EMD) absorbs approximately 30 W to power its logic circuits.

The button is a Mosfet switch driven by a command from the BMS.

A voltage limiter is installed between the power terminals to prevent voltage spikes when the switch opens the circuit.

➢ *BMS FUNCTIONS*

(the Kuadro ECU communicates with the BMS ECU via the CAN bus

The battery control electronics carry out the following functions:

- **Overvoltage protection;**
- **Undervoltage protection;**
- **Overcurrent protection;**
- **Overheat protection;**
- **Calculating state of charge (SOC);**
- **Calculating cell balancing;**
- **Driving the safety switch;**
- **Double protection fuse;**
- **CAN interface;**
- **Error signals.**

The battery control electronics have the following functions:

- **Charge current and voltage request**
- **Maximum charge current and voltage indication**
- **Maximum discharge** current indication
- **Three safety levels:**
  - **“Warning**
  - **“Alarm”**
  - **Opening the safety switch**

2. TECHNICAL DATA

2.1 VEHICLE SPECIFICATIONS

2.2 MAINTENANCE SCHEDULE

2.3 PRODUCTS

2.1 VEHICLE SPECIFICATIONS

PETROL ENGINE SPECIFICATIONS

	125 cc	300 cc
TYPE	Single cylinder 4-stroke	Single cylinder 4-stroke
ENGINE CAPACITY	124 cm^3	278 cm^3
IDLE SPEED	1600 +/-100 rpm	1700 +/-100 rpm
MAX POWER	11.0 kW at 8500 rpm	18.2 kW at 7500 rpm
MAX TORQUE	16.0 kW at 3000 rpm	27.5 Nm at 3500 rpm
LUBRICATION	Forced circulation engine lubrication circuit with pump	Forced circulation engine lubrication circuit with pump
COOLING	Forced circulation cooling circuit with electric pump.	Forced circulation of cooling fluid
SPARK PLUG	NGK CR8EKB	NGK CR8EKB
PIPE	Unleaded petrol/gasoline (95 R.O.N.)	Unleaded petrol (95 R.O.N.)
EMISSIONS COMPLIANCE	EURO 3	EURO 3

ELECTRIC MOTOR SPECIFICATIONS

	125/300 cc
ELECTRIC MOTOR	Three phase alternating current BRUSHLESS permanent magnet motor. Power output when operating as motor: 2.6 kW. Max. torque: 15Nm. Max. power output when operating as generator: 1.5 kW. Power supply voltage: 400 Volt AC

VEHICLE SPECIFICATIONS

	125/300 cc
FRONT BRAKE	Dual 240 mm hydraulic disc brakes operated from right hand lever on handlebar
REAR BRAKE	Single 240 mm hydraulic disc brake operated from left hand lever on handlebar
INTEGRAL BRAKING SYSTEM	All three disc brakes operated simultaneously from pedal on footrest platform.

2.2 MAINTENANCE SCHEDULE

TABLE

Km x 1,000	1	5	10	15	20	25	30	35	40	45	50	*55*	60
Roller bearing - Driven pulley			L		L		L		L		L		L
Safety locks	I		I				I				I		I
Spark plug			R		R		R		R		R		R
Driving belt			I	R	I		R		I	R	I		R
Throttle control	A		A		A		A		A		A		A
Air filter			C		C		C		C		C		C
Oil filter	R		R		R		R		R		R		R
CVT filter			C		C		C		C		C		C
Valve clearance			A				A				A		
Electrical system and battery	I		I		I		I		I		I		I
Brake lever	L		L		L		L		L		L		L
Brake fluid *	I		I		I		I		I		I		I
Coolant*	I		I		I		I		I		I		I
Engine oil	R	I	R	I	R	I	R	I	R	I	R	I	R
Hub oil	R		I		R		I		R		I		R

I: CHECK, CLEAN AND ADJUST, LUBRICATE OR REPLACE IF NECESSARY **C**: CLEAN, **R**: REPLACE, **A**: ADJUST, **L**: LUBRICATE * Replace every 2 years

- At each service, check for updates for the software in each ECU

TABLE

Km x 1,000	1	5	10	15	20	25	30	35	40	45	50	*55*	60
Headlight aiming				A			A			A			A
Brake pads	I	I	I	I	I	I	I	I	I	I	I	I	I
CVT sliders / rollers			R		R		R		R		R		R
Tyre pressure and wear	I		I		I		I		I		I		I
Test ride	I		I		I		I		I		I		I
Radiator (external cleaning)				I			I			I			I
Suspension	I		I		I		I		I		I		I
Steering	A		A		A		A		A		A		A
Roll lock calliper control cable	A		A		A		A		A		A		A
Cables				L			L			L			L

I: CHECK, CLEAN AND ADJUST, LUBRICATE OR REPLACE IF NECESSARY

C: CLEAN, **R**: REPLACE, **A**: ADJUST, **L**: LUBRICATE * Replace every 2 years

- At each service, check for updates for the software in each ECU

IF THE VEHICLE IS USED IN PARTICULARLY DUSTY CONDITIONS, THE MAINTENANCE INTERVALS FOR THE AIR FILTER AND CVT FILTER MUST BE SHORTENED TO PREVENT DAMAGE TO THE ENGINE

2.3 PRODUCTS

TABLE OF RECOMMENDED PRODUCTS

PRODUCT	DESCRIPTION	SPECIFICATIONS	QUANTITY
AGIP GEAR 80W-90	Transmission oil	SAE 80W-90, API GL-4 multigrade mineral oil	250 cm^3
AGIP CITY HI TEC 4T	Engine oil	SAE 5W-40 synthetic oil, API SL, ACEA A3, JASO MA	1.3 lt.(0.34 US gal) (complete fill) 1.2 lt.(0.31 US gal) (at oil change)
AGIP BRAKE 4	Brake fluid	FMWSS DOT 4 synthetic fluid	–
AGIP PERMANENT SPEZIAL	Coolant	Monoethylene glycol based antifreeze fluid, CUNA NC 956-16.	~ 2 lt (0.52 US gal)

3. DIAGNOSTICA

3.1 NAVIGATOR

3.2 PGDS

3.3 BMS

3.1 NAVIGATOR

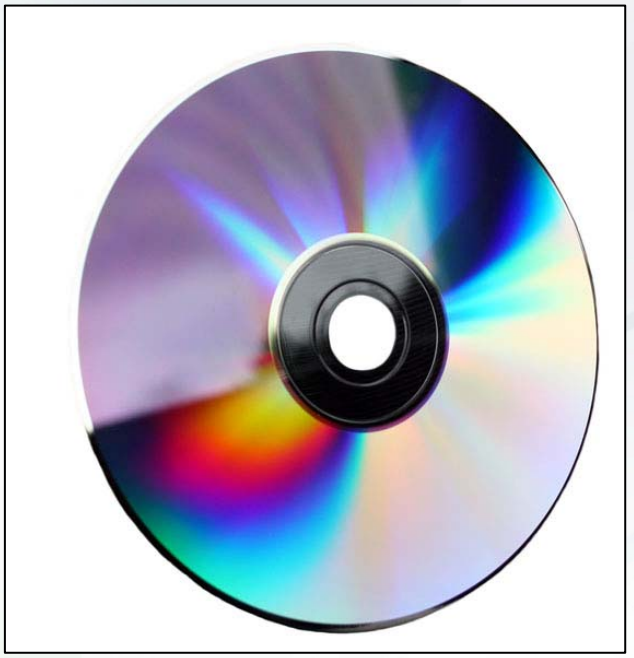
Diagnosis Tool

Navigator is the fundamental tool used for the static and dynamic testing of all Piaggio vehicle electronic systems.
The lowest recommended firmware version for using the diagnostic environment is 1.0.7.5 (required for reprogramming the BMS of the MP3 Hybrid)

3.2 PGDS

PIAGGIO GROUP DIAGNOSTIC SOFTWARE

PGDS is currently the best software solution for use with the Navigator diagnostic interface.
The minimum recommended software version for using the diagnostic environment is 8.0.1



Diagnosing the KUADRO Electric Management System

ECU INFO

Drawing number	**00641231**
Hardware version number	H0001203
Hardware version number	07
Software version number	P7PH1D-0300
Mapping	**0208A006 (usually the reference INFO for calibration updates)**
Type-approval code	KUAD07
ISO code	35 12 87 41 33
Author of last programming	**DNX8T0000123 (Navigator if ripped by dealer)**
Reprogramming or production date	**01/06/2010** (coherence check, not automatically activated, set by user)
ECU serial number	000000000
Week/Year of production	00/00
DSP firmware version	00 00
Miniboot firmware version	MBPI03-0100
Boot firmware version	**BTPI03-0205** (boot firmware update may be needed in certain cases)

Diagnosing the KUADRO Electric Management System

PARAMETERS

Electric Motor Speed	rpm	Value which may be positive or negative (in reverse mode): from -1000 to +13500 ()
Three-phase bridge temperature	°C	Value measured by internal sensor in ECU: from - 5° to + 80° (raw signal)
High voltage bridge temperature	°C	Value measured by internal sensor in ECU: from - 5° to + 80° (raw signal)
Electric motor temperature	°C	Value measured by internal sensor in stator: from -5° to + 110° (raw signal)
Traction battery voltage	V	Battery cannot be used below 27 V (LED 'No charge' red), 20V LED off, Inverter power switched off below 32 V
12V battery voltage	V	Value measured during DC/DC operation (STATES): as high as 14.5 Volt (difference relative to value measured with air flow meter)
Traction battery current	A	Value measured during operation (max 110 A peak): during recovery 35A, when charging from mains 25A
High voltage condenser voltage	V	High voltage condenser voltage (approx. 250 Volt 450 Volt), with vehicle in use and during mains charging 400V
3.3 V power	V	3.3 V Power (generated by internal transformer of 36V line, used to power electronics), taken from both 12V and 36V lines
8 V power	V	8 V Power (generated by internal transformer of 36V line, used to power electronics) 6.9 (if 36 V line not available) 8V
14 V power	V	14 V Power (generated by internal transformer of 36V line, used to power sensors/actuators)
Power electronics drive power	V	Power electronics drive power: 12V
Battery management system ECU (BMS) power	V	Battery management system (BMS) ECU power: 12V (7V is measured on wiring harness with multimeter)
Battery state of charge (SOC)	%	Battery state of charge (SOC) 0% – 100%, no power available below 20%, at 0%, battery contains residual charge of 20%
Electric motor torque	Nm	Electric motor torque from (maximum electric motor positive torque) to (maximum electric motor negative torque): 11Nm for 125ie, 15 Nm for 300 ie
Internal combustion engine torque	Nm	Petrol engine torque: -1 to 16Nm (125ie), -1.7 to 25.5 Nm (300ie)
Maximum positive torque of electric motor	Nm	Maximum positive torque of electric motor: -4 to 11Nm (125ie), -4 to 15 Nm (300 ie), inverse value for reverse mode
Maximum negative torque of electric motor	Nm	Maximum negative torque of electric motor: -11Nm (125ie) -15 Nm (300 ie)
Total torque request	Nm	Total torque available: -10 to 35 Nm (125ie), -10 to 70 Nm (300ie)
Reference current for mains charging	A	Value measured during charging (max 25 A if battery is discharged): *1.2

Diagnosing the KUADRO Electric Management System

STATES

Electric motor phase synchronisation	Phase set/Phase not set
Key	On/Off
Mains charging switch	Closed/Open
Kuadro cooling fan	On/Off
Mains charging indicator	On/Off
Enable DC/DC	On/Off
Buzzer	On/Off
Battery current dependent limiting	**Remark 1**
Battery voltage dependent limiting	**Remark 2**
SOC dependent limiting	**Remark 3**
Temperature dependent limiting	**Remark 4**
Kuadro operating mode	Hybrid Charge - Hybrid Power - Electric - Electric Reverse - Mains charge - No Mode
Kuadro state	phase reset in progress - normal - charging from mains - initialising - malfunction - ready for mains charging and key ON - Power Latch
MMP_SMP serial activity	Expert Mode
FSM Scooter Status	Expert Mode
FSM State of Charge	Expert Mode
DSP Fault	Expert Mode
PPC Fault	Expert Mode
Safety Error 2	Expert Mode
Safety Error 3	Expert Mode

Diagnosing the KUADRO Electric Management System

STATES

Remark 1	Value varying from 1 -> 0 (Total torque limiting) 0.01-0.25 (Very severe torque limiting) 0.26-0.50 (Severe torque limiting) 0.51-0.79 (Torque limiting) 0.80-0.99 (Moderate torque limiting) 1 No torque limiting
Remark 2	Value varying from 0 to 1 -> 0 (Total torque limiting) 0.01-0.25 (Very severe torque limiting) 0.26-0.50 (Severe torque limiting) 0.51-0.79 (Torque limiting) 0.80-0.99 (Moderate torque limiting) 1 No torque limiting
Remark 3	Value varying from 0 to 1 -> 0 (Total torque limiting) 0.01-0.25 (Very severe torque limiting) 0.26-0.50 (Severe torque limiting) 0.51-0.79 (Torque limiting) 0.80-0.99 (Moderate torque limiting) 1 No torque limiting
Remark 4	Value varying from 0 to 1 -> 0 (Total torque limiting) 0.01-0.25 (Very severe torque limiting) 0.26-0.50 (Severe torque limiting) 0.51-0.79 (Torque limiting) 0.80-0.99 (Moderate torque limiting) 1 No torque limiting

All of these torque limiting modes are managed by the KUADRO system, which limits available torque and activates the mains charge indicator lamp.
In this case, the system is indicating that a torque limiting function is in effect, ranging from total torque limiting to partial torque limiting.

Diagnosing the KUADRO Electric Management System

ACTIVATION

1	Error clearing	Perform this operation after rectifying the fault
2	Buzzer	Used to ascertain whether the KUADRO is capable of managing the buzzer autonomously, such as when in electric reverse mode, for example
3	Mains charging indicator	Bear in mind that this indicator is also used by the KUADRO to indicate when battery limiting is active (it is important to check that this indicator is functioning correctly)
4	Battery state of charge indicator (SOC)	Indicated value increases by 25% every second: 0 - 25% - 50% - 75% - 100% and then decreases to 0 (SOC State Of Charge)
5	Kuadro cooling fan	Kuadro cooling fan
6	Operating mode indicator	Changes LCD DISPLAY mode
7	12V DC/DC	During activation, check measure effective output with multimeter on service battery (15 V)
8	Internal combustion engine start	Internal combustion engine start

Diagnosing the KUADRO Electric Management System

SETTINGS

Reset motor phase synchronisation	Carry out in the case of replacing the Kuadro ECU - electric motor – motor rotation sensor – or removal of motor components.

Resetting Electric Motor Phase Synchronisation

1. Place the vehicle on the centre stand, with the rear wheel free to turn
2. From the PGDS settings, enable Reset
3. Key OFF (Power latch)
4. Key ON
5. Ensure that the reset procedure has been performed correctly - there should be no state indication on the instrument panel display.
6. Start the petrol engine and increase engine speed progressively to approximately 7000 rpm.
7. The petrol engine will switch off automatically
8. The Kuadro starts to phase-synchronise the electric motor, rotating the rear wheel
9. The charge indicator lamp flashes to indicate that the reset process is complete
10. Key OFF (Power latch)
11. Key ON, if the Electric motor phase synchronisation **state** is “synchronised”, the message “**Motor Phase Synchronisation completed successfully**”will be displayed

Diagnosing the KUADRO Electric Management System

AMBIENT PARAMETERS

1	Electric Motor Speed	rpm
2	Throttle aperture percentage	%
3	Electric motor torque	Nm
4	Operating mode	-
5	Battery state of charge (SOC)	%
6	Traction battery voltage	Volt
7	Electric motor temperature	°C
8	Kuadro ECU temperature	°C

Diagnosing the KUADRO Electric Management System

ERRORS

P0600	Safety 3 communication line (diagnosis of SPI communication line between DSP and PPC)	In the event of a fault, attempt reprogramming, then replace INVERTER if necessary	INT
P0602	Internal communication line	In the event of a fault, attempt reprogramming, then replace INVERTER if necessary	INT
P0A00	Electric motor temperature	If this error is indicated, check the electric motor temperature sensor by allowing the motor to cool to ambient temperature and measuring the electric motor temperature sensor resistance values as indicated in the manual	EXT
P0A01	Electric motor temperature sensor	Indicatively, the sensor operates within a range from -5°C and +110°C (with a tolerance of ± 10°C). The self-diagnosis system identifies an “open circuit” fault state. (In reality, the system receives no indication of a temperature increase during use, so the temperature value remains at -4/-5°C). In the event of short circuit, self-diagnosis is not activated and instead, a temperature value of 130°C is indicated on the Navigator, which does not drop even while the motor is effectively cooling. The system nonetheless cuts out due to motor overheating, the mains charge indicator lamp lights and the electric motor cuts out. In the event of a fault, carry out the checks described in the service station manual.	EXT
P0A02	Inverter current "V" phase	This error is generated if electric motor phase current is higher than +45A or lower than -45A. Check phases with a multimeter as described in the SSM	INT
P0A03	Inverter current "W" phase	This error is generated if electric motor phase current is higher than +45A or lower than -45A. Check phases with a multimeter as described in the SSM	INT
P0A04	High voltage bridge temperature	If value not within range between -50° and + 200°, replace INVERTER	INT

Diagnosing the KUADRO Electric Management System

ERRORS

P0A05	Three-phase inverter temperature sensor	If value not in range from -50° to + 200°, replace INVERTER	INT
P0A11	12V DC/DC converter enable command feedback	Replace INVERTER	INT
P0A14	Electric motor rotor position sensor	The sensor measures a voltage that varies in relation to the rotational position of the electric motor rotor. The value measures ranges varies from +4V to – 4V. Self-diagnosis is activated if the system voltages above +5.8V or -5.8V. In the event of a fault, consult the manual and perform the indicated checks.	EXT
P0A27	36 V battery pack voltage	The battery has an operating range from 27 to 42 Volts. However, if the system detects a voltage lower than 32 V, it cuts power to the inverter and inhibits electric traction. If the battery voltage drops below 32 V but not below 27 V, it may still be charged from the mains. If the battery voltage drops below 27 V, the battery must be replaced. The nominal voltage range within which the battery should remain in normal operating conditions is from 36 to 40 V, depending on the state of charge (rated voltage 37 V). The use of lithium ion technology ensures that the battery voltage is extremely stable, and battery voltage will almost always be approximately 37 V during power delivery and at any state of charge. In the event of a fault, perform the following checks: if the battery is disarmed (LED flashing red), test the BMS with the Navigator. If the battery is armed (LED flashing green), check battery voltage. If voltage measured exceeds 43V, replace the battery. If the battery voltage measured with the multimeter is between approx. 36 V and 41.5 V, replace the inverter.	EXT

Diagnosing the KUADRO Electric Management System

ERRORS

P0A28	36 V battery pack current	Current values range from 110A (with electric motor functioning as a motor) to -35A (with electric motor functioning as a generator). During mains charging, the value ranges from approx. – 16A to -24 A. Peak values may indicatively reach 110 A, whereas the value is approximately 60 A during stabilised operation (depending on state of charge). An error is generated if the battery current exceeds 150A. In the event of a fault, replace the inverter.	EXT
P0A29	12 V battery pack voltage	The system verifies the plausibility of the maximum voltage value, which should be 14.5V. The discrepancy between the direct reading made with the multimeter and the value read with Navigator is approximately 1 Volt. If the battery voltage exceeds 17 V, self-diagnosis is activated. Perform diagnosis of battery charging function from flywheel.	EXT
P0A30	36 V battery overcurrent protection hardware	Replace inverter	INT
P0A31	"U" and "V" current phase overcurrent protection hardware	Check phase sensor as described in SSM (motor rotation and phase sensor) and replace inverter if necessary (inverter)	INT
P0A32	Overcurrent protection hardware	Replace inverter	INT
P0A33	Overvoltage protection hardware	No signal, check rotation sensor then reset phase synchronisation and, if necessary, replace INVERTER	INT
P0A34	Excessive charge voltage from electric motor	No signal, check rotation sensor then reset phase synchronisation and, if necessary, replace INVERTER	INT
P0A35	Overcurrent protection hardware for transformer secondary winding	Replace inverter	INT
P0A36	Clamp circuit protection hardware	Replace inverter	INT

Diagnosing the KUADRO Electric Management System

ERRORS

P0A37	Power voltage circuit protection hardware	Check whether the traction battery is armed. If the battery is not armed, perform battery diagnosis. If the battery is armed, replace the inverter	INT
P0A38	Hardware diagnosis on DSP generic default	Check phase sensor as described in SSM (motor rotation and phase sensor) and replace inverter if necessary (inverter)	INT
P0A39	Hardware diagnosis on pre-charge circuit	Replace inverter	INT
P0A40	Hardware diagnosis on DSP watchdog intervention	Replace inverter	INT
P1480	Electric fan in helmet compartment (Kuadro)	The diagnostic system verifies plausibility of fan rotation signal. In the event of malfunction, carry out the checks described in the service station manual. (inverter cooling fan)	EXT
P1481	Relay for electric fan in helmet compartment (Kuadro)	Note that the relay is located inside the Kuadro ECU. Replace inverter (inverter)	EXT
P1650	Charge indicator light command	System detects an open circuit, positive line is short circuited to ground. In the event of a fault, check the electrical system between the inverter and the indicator lamp, as described in the SSM (charge indicator and buzzer)	INT / EXT
P1657	Battery state of charge indicator (SOC)	Perform checks indicated in SSM (state of charge indicator)	INT / EXT
P1658	Operating state indicator	Check wiring between inverter and instrument cluster and perform diagnosis as described in SSM (state of charge indicator)	INT
P1659	Buzzer command	Perform checks indicated in SSM (state of charge indicator)	INT / EXT

Diagnosing the KUADRO Electric Management System

ERRORS

P1A00	Three-phase inverter direct current power	Replace inverter	INT
P1A01	Clamp circuit	Replace inverter	INT
P1A27	36 V battery pack voltage sensor	Replace inverter	INT
P1A28	36 V battery pack current sensor	Replace inverter	INT
P2A27	Coherence between 36V battery pack voltage sensor and battery management system ECU (BMS)		INT
P2A28	Coherence between 36V battery pack current sensor and battery management system ECU (BMS)		INT
U1602	No signals on CAN line with vehicle CAN in Bus OFF state	Check wiring harness	INT/EXT
U1703	CAN line to battery management system ECU (BMS)	Check ECU power and connection to CAN line	INT / EXT
U1704	CAN line towards hold assist ECU (NST)	Check ECU power and connection to CAN line	INT / EXT
U1705	CAN line to engine management system ECU (KUBO)	Check ECU power and connection to CAN line	INT / EXT
P2023	Switch signal present with vehicle in use	Release procedure	EXT
P1612	Safety error 2	Replace inverter	INT
P1610	Safety error 3	Replace inverter	INT
P0606	CPU error	Replace inverter	INT
P0604	RAM error	Replace inverter	INT

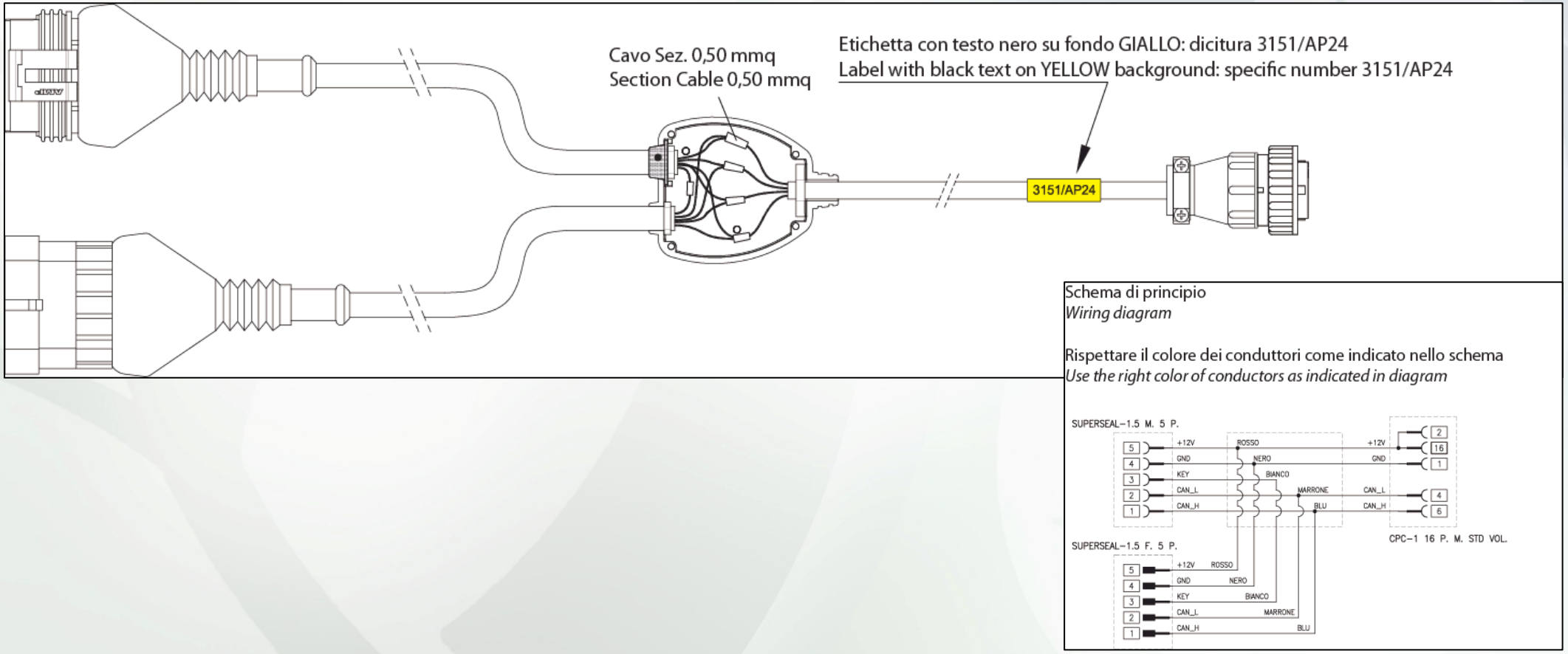
Diagnosing the KUADRO Electric Management System

ERRORS

P0481	Kuadro fan power unit diagnosis	The inverter fan power unit, located inside the Kuadro ECU, diagnosis an open circuit state with a voltage of zero or less than 8.5 V in the event of poor conductivity. This fault is diagnosed in the absence of the electric fan command signal. If the electric fan is commanded and the system measures residual voltage values above 3 V on the ground, a short circuit to positive is diagnosed. Check the electric fan power system as described in the SSM (inverter cooling fan)	INT / EXT
P0482	Internal Kuadro fan diagnosis	Replace inverter	INT / EXT
P2027	Software compatibility with Kubo ECU	Check Kubo ECU software	INT
P2020	Battery management system (BMS) ECU power supply feedback (charge mode only)	Check BMS wiring harness for short circuit to ground, minimum value 9V	INT / EXT
P2021	Battery management system ECU (BMS)	Check BMS diagnosis	INT
P2022	Battery discharged too rapidly	Check BMS diagnosis	INT
P2024	36V battery danger	Check BMS diagnosis	INT
P2025	Software compatibility with BMS	Check BMS ECU software	INT
P2026	Generic BMS error	Check BMS diagnosis	INT

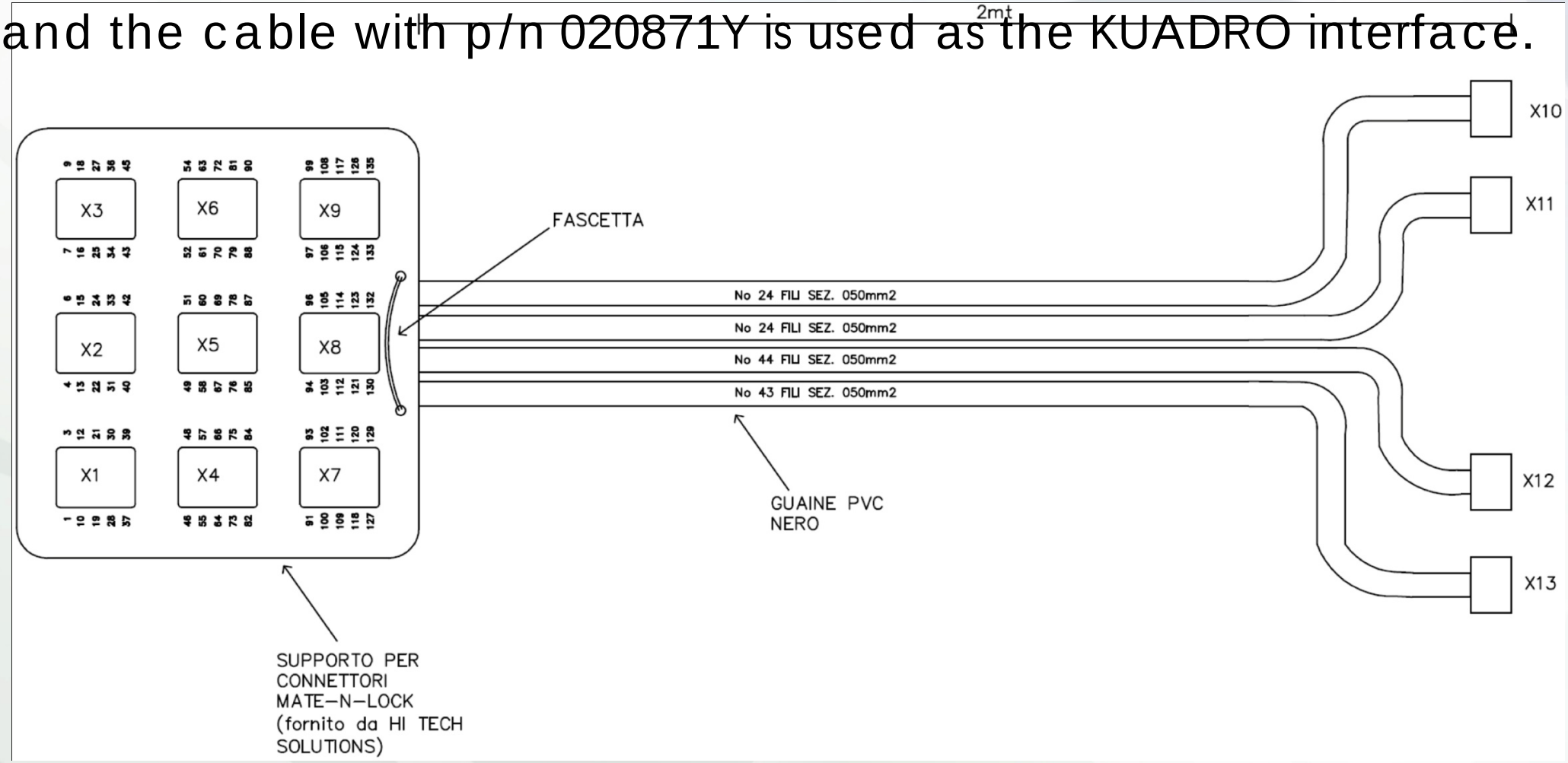
3.3 BMS INTERFACE

The interface between the Navigator and the BMS (Battery Management System) consists of a specific cable (p/n 020878Y), connected between the male connector of the Navigator and the female 5-way connector on the BMS.



3.4 VEHICLE INTERFACE

The vehicle interface consists of the specific cable (p/n 020687Y), whereas the cable with p/n 020870Y is used as the KUBO ECU interface
and the cable with p/n 020871Y is used as the KUADRO interface.



BMS Battery Management System Diagnosis

ECU info

Producer	Efi Technology	Indicates the manufacturer
Compatibility	30	Identifies whether cross-ECU compatibility (BMS-KUADRO-KUBO) is implemented in this software
HC8 Kernel Version	11	
HC8 Application Version	31	
ATMEL Kernel Version	6	
ATMEL Application Version	**29**	
ATMEL Calibration	**30**	
Battery Serial Number	1555	
Encryption	Yes/No	
Mapping	**2930001***	Information identifying the calibration running on the BMS, the name indicates the ' ATMEL application version (29), the ATMEL calibration version (30) and a serial number (001)
Production Batch	90224	
Hardware Version		

BMS Battery Management System Diagnosis

PARAMETERS

Effective battery state of charge (SOC)	20...100 %	Value varying in relation to battery charge. 20% effective battery charge corresponds to 0% on indicator. Do not use the vehicle at lower values. Cross-check with multimeter, at 20% voltage should be approx. 35V Above 36.5 Volt, the indicator must show values above 0%.
Battery voltage	35...41 Volts	Value varying in relation to battery charge. If below 35 Volts, the minimum and maximum cell voltages must also be checked, as the battery may have been excessively discharged. If above 43 V, the battery will not arm (if this occurs with GREEN LED, replace battery)
Battery Current	**-50...100 A**	During mains charging: SOC -50% -> -20 A ±4 A (temp >5°) During mains charging: SOC 50% to 100% -> -20 A ±4 A up to 3 A (temp >5°) Key ON (Electric mode) current from 2 A to 8 A (wheel stationary/throttle closed)
Battery Temperature	**-30..+120°C**	+5°C...+50°C optimum battery performance (charging) -10°C...+5°C and from +50°C...+65°C reduced battery performance (charging) -5°C...+55°C optimum battery performance (discharging) -18°C...-5°C and from +55°C...+65°C reduced battery performance (discharging) Above 80°C dangerous battery conditions. In normal conditions, the battery temperature should be no more than approximately 30°C higher than the ambient temperature.

BMS Battery Management System Diagnosis

PARAMETERS

Maximum discharge current	**0...100 A**	Check that the current is <75 A in the red sector of the SOC indicator Check that the current is <50 A at a temp of -10°C<x<+55°C and an SOC >50%
Maximum charge current	**0...50 A**	SOC >75% current should be <30 A SOC <70% current should be <10 A at temp <5°C SOC <70% current should be <15 A at temp <55°C
Charge current reference	**0...22 A**	During mains charging: SOC<75% reference current is 20A ± 2A (5°C<temp<50°C) During mains charging: 75%<SOC<100% reference current drops to 3A (5°C<temp<50°C) T<5°C and >50°C, reference current drops
Charge voltage reference	**41.2 Volts**	Reference charge voltage limited to 40V±1V at t<0°C±1°C and t>60°C±1°C
Maximum cell voltage	3.5...4.1 Volts	If above 4.32 V, the battery will not arm (if this occurs with GREEN LED, replace battery) If above 4.12 V, excessive charge
Minimum cell voltage	3.5...4.1 Volts	Battery must be replaced if value is below 2.7 V. Below 2.5 V, diagnostic communications may not be available (battery does not arm) From 2.5 to 2.7 V, LED flashing permanently RED (battery does not arm) From 2.7 to 3.2 V, attempt mains charging From 3.2 to 3.5 V, battery does not function according to specifications From 3.5 to 4.1 V, battery functions correctly

BMS Battery Management System Diagnosis

STATES

Switch State	**Open**	RED LED, 1 flash every 5 sec
	Closed	GREEN LED, 1 flash every 5 sec
Switch aperture delay	**Off**	
	On	
Cell balancing ERROR	**Not detected**	
	Detected	
Cell Balancing	**Not active**	
	Active	
State of charge	**No charging**	
	Charging	
	Charge Complete	
	Not Valid Data	
BMS operating mode	**Stand-by**	
	Charge mode	
	Drive mode	
	Diagnostic mode	
Temperature too high for discharging warning	**Off**	
	On	

BMS Battery Management System Diagnosis

STATES

Temperature too high for discharging alarm	Off
	On
Voltage too high warning	Off
	On
Voltage too high alarm	Off
	On
Excessive discharge current warning	Off
	On
Excessive discharge current alarm	Off
	On
Excessive charge current warning	Off
	On
Excessive charge current alarm	Off
	On
Capacity too low	NO
	YES
Voltage too low Warning	Off
	On
Voltage too low Alarm	Off
	On

BMS Battery Management System Diagnosis

STATES

Air temperature	Off
	On
Current Sensor fault	Off
	On
Voltage Sensor fault	Off
	On
Switch fault	Off
	On
Internal fuse fault	Off
	On
Vehicle stop request	Off
	On
Internal communication error	Off
	On
Temperature too high for charging warning	Off
	On
Temperature too high for charging alarm	Off
	On

BMS Battery Management System Diagnosis

STATES

Temperature too low for discharging warning	Off
	On
Temperature too low for discharging Alarm	Off
	On
Temperature too low for charging warning	Off
	On
Temperature too low for charging Alarm	Off
	On

BMS Battery Management System Diagnosis

ACTIVATION

In the event of a traction battery fault, a freeze frame of all battery states is stored in a specific 'buffer' area of the ECU memory.

This INFO may be retrieved with the Navigator by accessing activations and clicking:

Download BMS Error Data Freeze Frame:

The Navigator reads the INFO and generates a binary format file (.bin)

The downloaded file is located in the directory:

C:\Programmi\Piaggiogroup\Bin\Bike\autodia\maps\save

The .bin file, identifiable by the name of the battery manufacturer and serial number in the file name itself, can only be consulted by specialised Piaggio technical support personnel. (e.g.: EFi1234) the battery 1234 serial number is indicated on the battery barcode label.

BMS Battery Management System Diagnosis

ERRORS

A battery that disarms is a very strong indication that thorough checks are necessary. The battery stores the causes and conditions of the fault in its internal buffer memory when it disarms.

The following table lists the possible errors viewable by opening the battery .bin file with the specific application FreezeFrameBMS.exe (supplied to specialised technical support personnel) and the respective battery faults.

BMS Battery Management System Diagnosis

ERRORS

DiagLine	Description	Error Codes	Error Decoding Set	Battery Change
0	VOLTAGE_WARNING_CELL_1	3,4	1	Detailed diagnosis of the system
1	VOLTAGE_ALARM_CELL_1	3,4	1	Detailed diagnosis of the system
2	VOLTAGE_OPEN_CELL_1	3,4	1	Detailed diagnosis of the system
3	TEMPERATURE_WARNING_CELL_1	1,2,3,4,5,6	3	Detailed diagnosis of the system
4	TEMPERATURE_ALARM_CELL_1	1,2,3,4,5,6	3	Detailed diagnosis of the system
5	TEMPERATURE_OPEN_CELL_1	1,2,3,4,5,6	3	Detailed diagnosis of the system
6	VOLTAGE_WARNING_CELL_2	3,4	1	Detailed diagnosis of the system
7	VOLTAGE_ALARM_CELL_2	3,4	1	Detailed diagnosis of the system
8	VOLTAGE_OPEN_CELL_2	3,4	1	Detailed diagnosis of the system
9	TEMPERATURE_WARNING_CELL_2	1,2,3,4,5,6	3	Detailed diagnosis of the system
10	TEMPERATURE_ALARM_CELL_2	1,2,3,4,5,6	3	Detailed diagnosis of the system
11	TEMPERATURE_OPEN_CELL_2	1,2,3,4,5,6	3	Detailed diagnosis of the system
12	VOLTAGE_WARNING_CELL_3	3,4	1	Detailed diagnosis of the system
13	VOLTAGE_ALARM_CELL_3	3,4	1	Detailed diagnosis of the system
14	VOLTAGE_OPEN_CELL_3	3,4	1	Detailed diagnosis of the system
15	TEMPERATURE_WARNING_CELL_3	1,2,3,4,5,6	3	Detailed diagnosis of the system
16	TEMPERATURE_ALARM_CELL_3	1,2,3,4,5,6	3	Detailed diagnosis of the system

BMS Battery Management System Diagnosis

ERRORS

DiagLine	Description	Error Codes	Error Decoding Set	Battery Change
17	TEMPERATURE_OPEN_CELL_3	1,2,3,4,5,6	3	Detailed diagnosis of the system
18	VOLTAGE_WARNING_CELL_4	3,4	1	Detailed diagnosis of the system
19	VOLTAGE_ALARM_CELL_4	3,4	1	Detailed diagnosis of the system
20	VOLTAGE_OPEN_CELL_4	3,4	1	Detailed diagnosis of the system
21	TEMPERATURE_WARNING_CELL_4	1,2,3,4,5,6	3	Detailed diagnosis of the system
22	TEMPERATURE_ALARM_CELL_4	1,2,3,4,5,6	3	Detailed diagnosis of the system
23	TEMPERATURE_OPEN_CELL_4	1,2,3,4,5,6	3	Detailed diagnosis of the system
24	VOLTAGE_WARNING_CELL_5	3,4	1	Detailed diagnosis of the system
25	VOLTAGE_ALARM_CELL_5	3,4	1	Detailed diagnosis of the system
26	VOLTAGE_OPEN_CELL_5	3,4	1	Detailed diagnosis of the system
27	TEMPERATURE_WARNING_CELL_5	1,2,3,4,5,6	3	Detailed diagnosis of the system
28	TEMPERATURE_ALARM_CELL_5	1,2,3,4,5,6	3	Detailed diagnosis of the system
29	TEMPERATURE_OPEN_CELL_5	1,2,3,4,5,6	3	Detailed diagnosis of the system
30	VOLTAGE_WARNING_CELL_6	3,4	1	Detailed diagnosis of the system
31	VOLTAGE_ALARM_CELL_6	3,4	1	Detailed diagnosis of the system
32	VOLTAGE_OPEN_CELL_6	3,4	1	Detailed diagnosis of the system
33	TEMPERATURE_WARNING_CELL_6	1,2,3,4,5,6	3	Detailed diagnosis of the system
34	TEMPERATURE_ALARM_CELL_6	1,2,3,4,5,6	3	Detailed diagnosis of the system

BMS Battery Management System Diagnosis

ERRORS

DiagLine	Description	Error Codes	Error Decoding Set	Battery Change
35	TEMPERATURE_OPEN_CELL_6	1,2,3,4,5,6	3	Detailed diagnosis of the system
36	VOLTAGE_WARNING_CELL_7	3,4	1	Detailed diagnosis of the system
37	VOLTAGE_ALARM_CELL_7	3,4	1	Detailed diagnosis of the system
38	VOLTAGE_OPEN_CELL_7	3,4	1	Detailed diagnosis of the system
39	TEMPERATURE_WARNING_CELL_7	1,2,3,4,5,6	3	Detailed diagnosis of the system
40	TEMPERATURE_ALARM_CELL_7	1,2,3,4,5,6	3	Detailed diagnosis of the system
41	TEMPERATURE_OPEN_CELL_7	1,2,3,4,5,6	3	Detailed diagnosis of the system
42	VOLTAGE_WARNING_CELL_8	3,4	1	Detailed diagnosis of the system
43	VOLTAGE_ALARM_CELL_8	3,4	1	Detailed diagnosis of the system
44	VOLTAGE_OPEN_CELL_8	3,4	1	Detailed diagnosis of the system
45	TEMPERATURE_WARNING_CELL_8	1,2,3,4,5,6	3	Detailed diagnosis of the system
46	TEMPERATURE_ALARM_CELL_8	1,2,3,4,5,6	3	Detailed diagnosis of the system
47	TEMPERATURE_OPEN_CELL_8	1,2,3,4,5,6	3	Detailed diagnosis of the system
48	VOLTAGE_WARNING_CELL_9	3,4	1	Detailed diagnosis of the system
49	VOLTAGE_ALARM_CELL_9	3,4	1	Detailed diagnosis of the system
50	VOLTAGE_OPEN_CELL_9	3,4	1	Detailed diagnosis of the system
51	TEMPERATURE_WARNING_CELL_9	1,2,3,4,5,6	3	Detailed diagnosis of the system
52	TEMPERATURE_ALARM_CELL_9	1,2,3,4,5,6	3	Detailed diagnosis of the system
53	TEMPERATURE_OPEN_CELL_9	1,2,3,4,5,6	3	Detailed diagnosis of the system
54	VOLTAGE_WARNING_CELL_10	3,4	1	Detailed diagnosis of the system
55	VOLTAGE_ALARM_CELL_10	3,4	1	Detailed diagnosis of the system

BMS Battery Management System Diagnosis

ERRORS

DiagLine	Description	Error Codes	Error Decoding Set	Battery Change
56	VOLTAGE_OPEN_CELL_10	3,4	1	Detailed diagnosis of the system
57	TEMPERATURE_WARNING_CELL_10	1,2,3,4,5,6	3	Detailed diagnosis of the system
58	TEMPERATURE_ALARM_CELL_10	1,2,3,4,5,6	3	Detailed diagnosis of the system
59	TEMPERATURE_OPEN_CELL_10	1,2,3,4,5,6	3	Detailed diagnosis of the system
60	CURRENT_WARNING	1,2	1	Detailed diagnosis of the system
61	CURRENT_ALARM	1,2	1	Detailed diagnosis of the system
62	CURRENT_OPEN	1,2	1	Detailed diagnosis of the system
63	VOLTAGE_WARNING_PACK	3,4	1	Detailed diagnosis of the system
64	VOLTAGE_ALARM_PACK	3,4	1	Detailed diagnosis of the system
65	VOLTAGE_OPEN_PACK	3,4	1	Detailed diagnosis of the system
66	COMMUNICATION_CELL_2	7,8,9,10	1	**YES**
67	COMMUNICATION_CELL_3	7,8,9,10	1	**YES**
68	COMMUNICATION_CELL_4	7,8,9,10	1	**YES**
69	COMMUNICATION_CELL_5	7,8,9,10	1	**YES**
70	COMMUNICATION_CELL_6	7,8,9,10	1	**YES**
71	COMMUNICATION_CELL_7	7,8,9,10	1	**YES**
72	COMMUNICATION_CELL_8	7,8,9,10	1	**YES**
73	COMMUNICATION_CELL_9	7,8,9,10	1	**YES**
74	COMMUNICATION_CELL_10	7,8,9,10	1	**YES**
75	VOLTAGE_CONGRUENCY	11	1	Detailed diagnosis of the system

BMS Battery Management System Diagnosis

ERRORS

DiagLine	Description	Error Codes	Error Decoding Set	Battery Change
76	HARDWARE_CHECK_CELL_1	1,2,3	2	**YES**
77	HARDWARE_CHECK_CELL_2	1,2,3	2	**YES**
78	HARDWARE_CHECK_CELL_3	1,2,3	2	**YES**
79	HARDWARE_CHECK_CELL_4	1,2,3	2	**YES**
80	HARDWARE_CHECK_CELL_5	1,2,3	2	**YES**
81	HARDWARE_CHECK_CELL_6	1,2,3	2	**YES**
82	HARDWARE_CHECK_CELL_7	1,2,3	2	**YES**
83	HARDWARE_CHECK_CELL_8	1,2,3	2	**YES**
84	HARDWARE_CHECK_CELL_9	1,2,3	2	**YES**
85	HARDWARE_CHECK_CELL_10	1,2,3	2	**YES**
86	HI_RES_CURRENT_CONGRUENCY	13	1	**YES**
87	LOW_RES_CURRENT_CONGRUENCY	12	1	**YES**
88	BLOWN_FUSE_FAILURE	6,7	2	Detailed diagnosis of the system
89	CHARGE_SWITCH_FAILURE	8	2	**YES**
90	DISCHARGE_SWITCH_FAILURE	8	2	**YES**
91	TEMPERATURE_CONGRUENCY	11	1	Detailed diagnosis of the system
92	WAKE_UP_FAILURE	9,10,11	2	Detailed diagnosis of the system
93	MOSFET_TEMPERATURE_SENSOR_FAILURE	5.6	1	YES
94	SHUNT_TEMPERATURE_SENSOR_FAILURE	5.6	1	YES
95	SOFTWARE_COMPATIBILITY	7,8	3	Check Software Compatibility KUBO/KUADRO/BMS

4. VEHICLE PRE-DELIVERY PROCEDURE

4.1 BEFORE DELIVERING THE VEHICLE ...

4.2 CHECKING TIGHTENING TORQUES

4.3 ELECTRICAL SYSTEM

4.4 CHECKING FLUID LEVELS

4.5 ROAD TEST

4.6 CHECKS AFTER ROAD TEST

4.7 FUNCTIONAL TEST

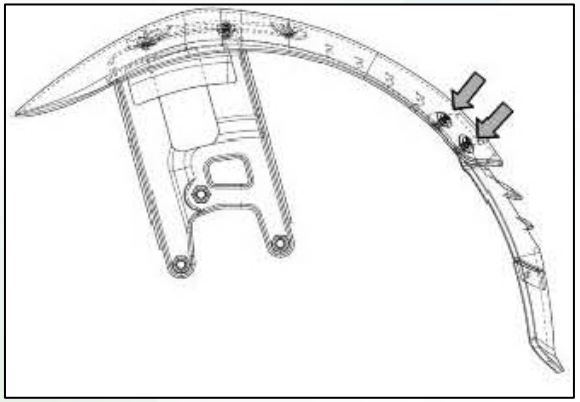
4.8 PHASE-SYNCHRONISING THE ELECTRIC MOTOR

4.1 CARRY OUT THE FOLLOWING CHECKS BEFORE DELIVERING THE VEHICLE:

Fit the plastic cover supplied onto the joint onto the steering tube as shown in the figure.

Proceed as follows if the customer requests installation of splash guards on the vehicle:

- Fit the splash guard inside the mudguard as shown in the figure, aligning the 4 anchor holes



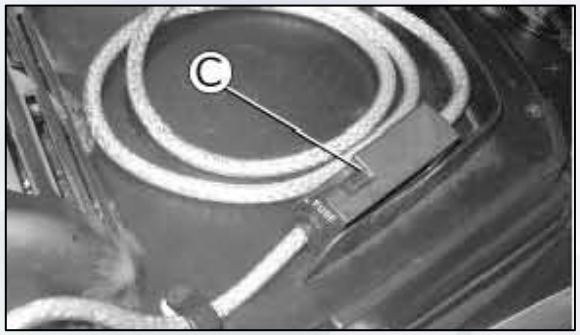
- Fit the 4 washers and the 4 screws on the outer side of the mudguard and tighten to a torque of 2 - 3

CHARGE THE TRACTION BATTERY FULLY BEFORE DELIVERING THE VEHICLE TO THE CUSTOMER.

Activation procedure for traction battery:

The LED on the battery flashes red (approx. 1 flash every 5 sec.)
Turn the ignition key "ON"
Press and hold the traction battery activation button for 1 second.
The LED on the battery flashes green (approx. 1 flash every 5 sec.)
Turn the ignition key "OFF".
Wait 10 seconds.
Turn the ignition key "ON" and check that the charge indicator displays the battery charge state.

➢ To charge from the mains, lift the saddle and remove the charging plug, twisting slightly anticlockwise. An adaptor must be used in order to charge from the household mains. This adapter is supplied with the vehicle and kept in the rear case. The power cable is fitted with a fused device “C”.



REPLACE THE CHARGING PLUG CORRECTLY IN ITS SEAT

Error clearing

During the pre-delivery procedure, after completing all the operations indicated, always remember to connect the Navigator and delete all the errors from all the ECUs and check that the ECU software is updated correctly (contact the Piaggio Help Desk for any queries):

1. Hold system
2. Kubo
3. Kuadro
4. BMS

ELECTRICAL CHARACTERISTICS

- MAXIMUM POWER ABSORPTION DURING CHARGING **1.2 kW**
- MAINS CHARGING CABLE FUSE: **10A**

VISUAL APPEARANCE CHECK

- PAINTWORK
- FITMENT OF PLASTIC COMPONENTS
- SCRATCHES
- DIRT

4.2 CHECKING TIGHTENING TORQUES

Visually check that there is a yellow mark on the following fastenings:

FRONT SUSPENSION

- Front left/right wheel fastener screws
- Speed sensor fastener screw
- Screw fastening pipe union – roll lock calliper

REAR SUSPENSION

- Upper and lower shock absorber fastener screws
- Screws fastening silencer mounting arm - engine
- Rear wheel axle nut

FRONT BRAKE

- left/right wheel brake disc fastener screws
- Screws fastening brake callipers and suspension elements
- Screws fastening brake pipe union - callipers

REAR BRAKE

- Screws fastening parking brake calliper
- Screws fastening parking brake calliper – brake cable
- Screws fastening brake pipe union - calliper

CHASSIS

- Nut fastening swing arm pin and engine/frame assembly
- Nut fastening stand pin - engine

4.3 ELECTRICAL SYSTEM

- Battery;
- Main switch
- Lights: high beam lights, low beam lights, taillights (front and rear) and relevant indicator lights;
- Adjusting headlight in accordance with applicable legislation;
- Front and rear brake light buttons and relative bulb;
- Turn indicators and relative indicator lights;
- Instrument panel light;
- Instruments: fuel and temperature gauges;
- Instrument warning lights;
- Horn;
- Electric starter;
- Stopping the engine with emergency stop switch;
- Opening the electric saddle release with remote control;
- Roll lock - release button

4.4 CHECKING FLUID LEVELS

- Hydraulic braking system fluid level;
- Roll lock system fluid level;
- Rear hub oil level;
- Engine coolant level;
- Engine oil level;

4.5 ROAD TEST

- Cold start;
- Instrument function;
- Response to throttle control;
- Stability under acceleration and braking;
- Function of front, rear and parking brake;
- Function of front and rear suspension;
- Abnormal noise;
- Roll lock system lock and release function;

4.6 STATIC TEST AFTER TEST RIDE

- Restart with engine warm;
- Idle speed stability (turning the handlebar);
- Uniform steering function;
- Leaks;
- Electric radiator fan function;

4.7 FUNCTIONAL TEST

- Hydraulic brake system: lever travel;
- Clutch: checking function;
- Engine: checking general function and for abnormal noise;
- Other: checking documents, chassis and engine number, tools and equipment, licence plate fitment, locks, tyre pressure, and fitment of rear view mirrors and any accessories specified.

4.8 PHASE-SYNCHRONISING THE ELECTRIC MOTOR

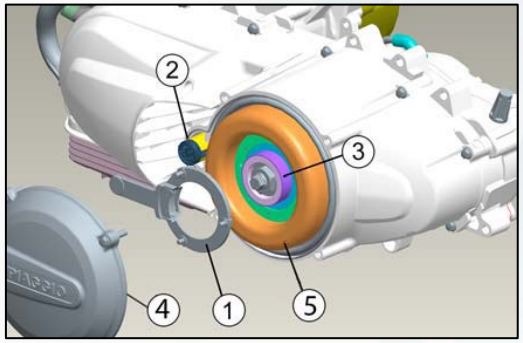
Resetting Electric Motor Phase Synchronisation

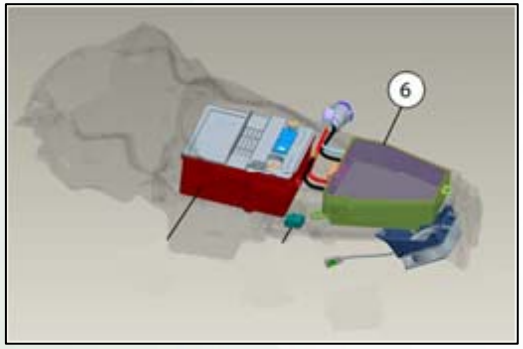
Phase synchronisation is reset with the Navigator. Subsequently, the ECU obliges the user to perform a specific procedure to resynchronise the phases.

Phase synchronisation reset procedure (Navigator):

must be performed each time any of the following components is removed or replaced:

1. Motor rotation sensor Electronics
2. Motor rotation sensor Connection
3. Rotor
4. Rotor cover
5. Stator
6. Pre-synchronised Kuadro ECU





Resetting Electric Motor Phase Synchronisation

1. Place the vehicle on the centre stand, with the rear wheel free to turn
2. From the PGDS settings, enable ***Reset phase synchronisation***
3. Key OFF (Power latch)
4. Key ON
5. Ensure that the reset procedure has been performed correctly - there should be no state indication on the instrument panel display.
6. Start the petrol engine and increase engine speed progressively to approximately 7000 rpm.
7. The petrol engine will switch off automatically
8. The Kuadro starts to phase-synchronise the electric motor, turning the rear wheel forwards and backwards.
9. The charge indicator light flashes when the synchronisation procedure is complete
10. Key OFF (Power latch)
11. Key ON and check STATES with the PGDS to ensure that the state ***"Electric motor phase synchronisation" is indicated as "synchronised"***.

Synchronisation procedure:
Forced by the ECU in the event of replacement:
New Kuadro ECU (not synchronised).

This procedure is managed entirely by the Kuadro ECU and may be monitored only with the Navigator.

1. Key ON
2. No state indication is shown on the instrument panel display.
3. Start the petrol engine and increase engine speed progressively to approximately 7000 rpm.
4. The petrol engine will switch off automatically
5. The Kuadro starts to phase-synchronise the electric motor, turning the rear wheel forwards and backwards.
6. The charge indicator light flashes when the synchronisation procedure is complete.
7. Key OFF (Power latch)
8. Key ON and check STATES with the PGDS to ensure that the state ***"Electric motor phase synchronisation" is indicated as "synchronised"***.

Synchronisation procedure:

It is imperative that phase-synchronisation is carried out with the transmission at operating temperature (e.g.: after riding a few kilometres (5)), so that the final drive is correctly lubricated and to ensure that the electric motor is phase-synchronised more precisely.

It is therefore advisable to ride a few kilometres after carrying out the phase-synchronisation procedure and then repeat the reset phase-synchronisation procedure with the Navigator.

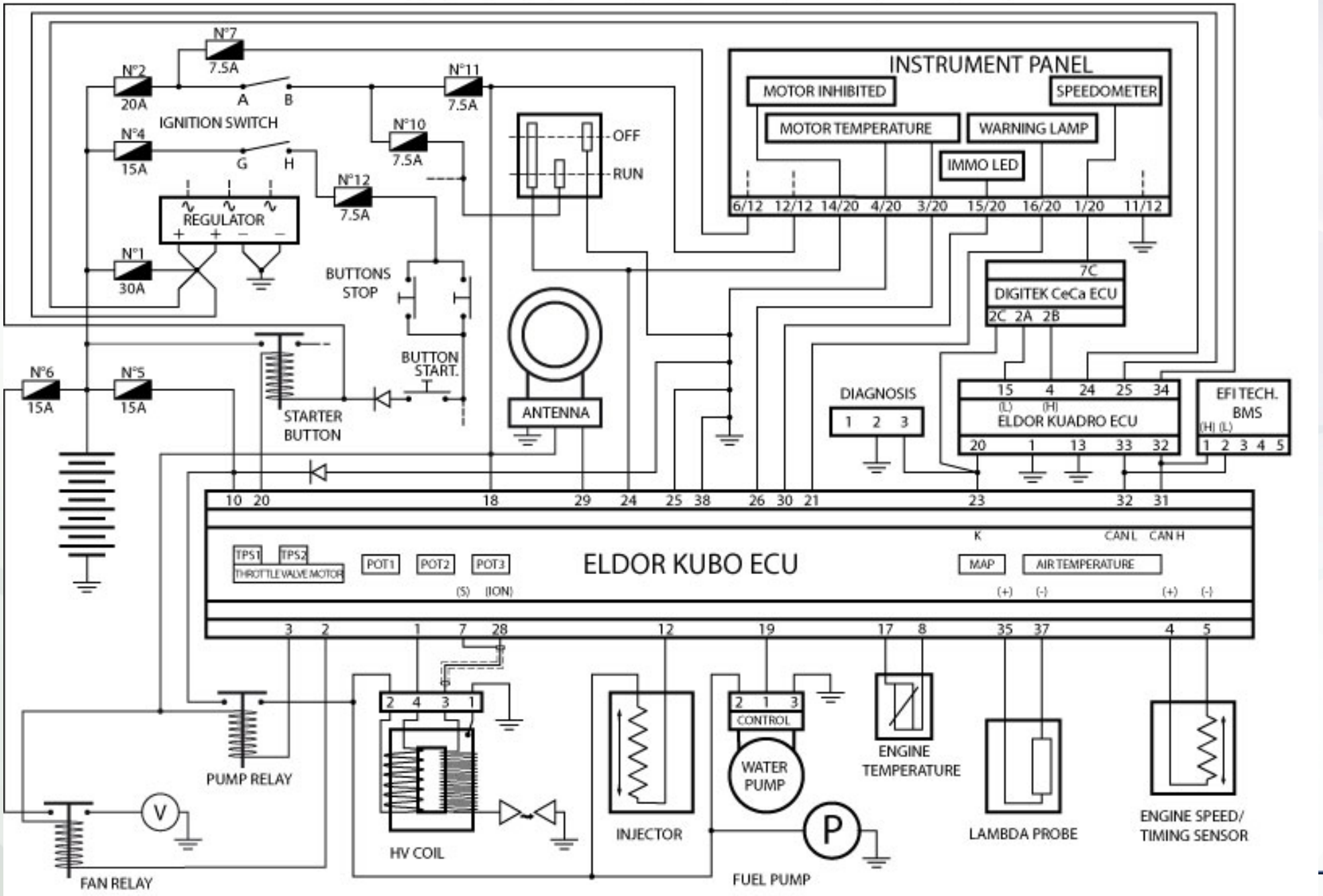
5. ELECTRICAL CIRCUIT DIAGRAMS

5.1 INJECTION SYSTEM DIAGRAM

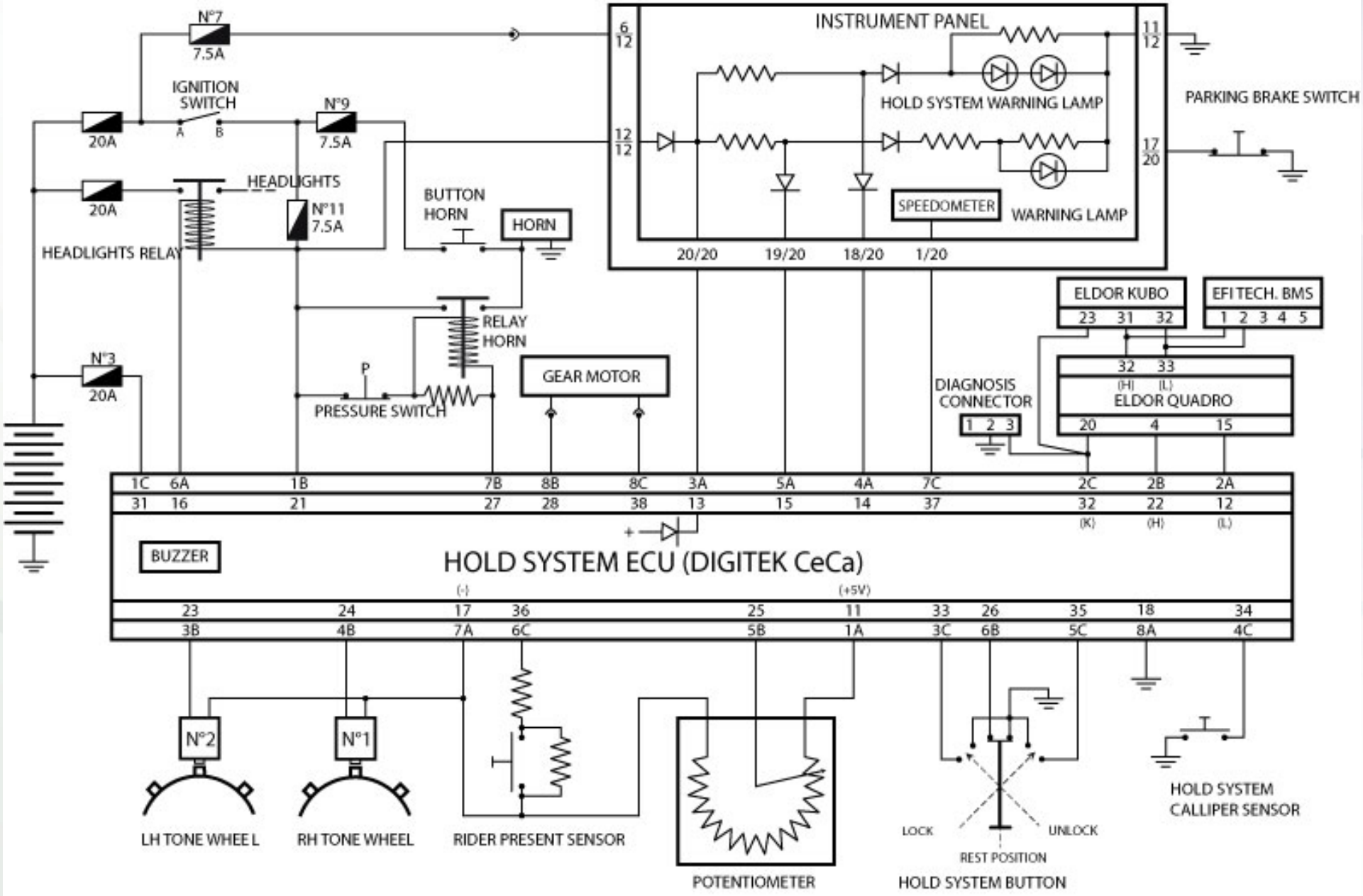
5.2 HOLD SYSTEM DIAGRAM

5.3 TRACTION SYSTEM DIAGRAM

INJECTION SYSTEM CIRCUIT DIAGRAM FOR MP3 125 HYBRID



HOLD SYSTEM CIRCUIT DIAGRAM, MP3 HYBRID



TRACTION SYSTEM CIRCUIT DIAGRAM, MP3 HYBRID